SOIL CONSERVATION

HENRY A. WALLACE
Secretary of Agriculture

HUGH H. BENNETT
Chief, Soil Conservation Service

VOL. V • NO. 6 ISSUED MONTHLY BY THE SOIL CONSERVATION SERVICE, DEPARTMENT OF AGRICULTURE, WASHINGTON DEC. • 1939

COOPERATIVE FARM FORESTRY—ANOTHER AVENUE TO BETTER LAND USE

By H. H. BENNETT [1]

THE only certainty about the work being done today to encourage better land use and conserve soil resources is that no single, simple panacea exists which will do the job. Every field and every block of land, on every farm and ranch, will have to be treated according to its individual needs and used according to its individual capabilities if true, Nation-wide conservation is to be achieved.

Farm forestry is one of the several types of work in which the Soil Conservation Service is interested. Since the recent congressional appropriation under the Norris-Doxey Act for such work, however, there has been considerable speculation about the place of farm forestry in the total Service program. This has resulted, perhaps, from an inclination to magnify out of true proportion the importance of this phase of our program. I trust this statement will not be interpreted as a minimization of farm forestry; that is not my intent. Work on the farm woodlands of the country is extremely important, but it is nevertheless only one part of the work that needs to be done.

To arrive at an accurate perspective of the Service's participation in the new, cooperative farm forestry program, it is essential first of all to remember the larger job the Service is trying to accomplish. Despite all the organizational developments of the past few years, the fundamental task of this agency is to encourage better use of land. Of course, recent laws of Congress, administrative orders, and the development of soil conservation districts have expanded the scope of our activity in several important directions. In some ways, the Service today is a far different organization from the agency that started helping farmers to control erosion back in the fall of 1933. The chief difference is that land-use adjustments are now being made over a broader area than ever before.

Throughout the country, the need for better husbandry of available resources is nowhere more acute or more widespread than on the 185 million acres of farm land that carry a forest cover. Comprising roughly 18 percent of our total agricultural area, woodlands are almost traditionally neglected by the farmer. Out of 138 million acres of farm woods with possible commercial value in the United States, only 30 percent, according to a Forest Service survey, is receiving anything like intelligent management. Only 1 percent is getting really first-class intensive treatment. Moreover, in far too many cases, farm forests are being definitely abused. Grazing, deliberate burning of undergrowth, and indiscriminate cutting year after year are steadily lowering the timber growth on thousands of farms—destroying its potential value for income production. Unless this tendency is checked and even reversed, we can never hope for a completely satisfactory solution of the Nation's land-use problem.

Trees have played an indispensable part in our erosion control program from the very beginning of such work. They have helped to tie down steep eroding hillsides that were no longer able to produce crops after years of continuous cultivation. They have furnished a sheltering cover for worn-out pastures that were practically devoid of forage and streaked with rainfall gashes. They have served to choke the growth of large gullies, to stabilize unsteady streambanks, and to screen off cultivated fields from soil-robbing winds. Altogether more than 440 million

[1] Chief, Soil Conservation Service, Washington, D. C.

trees and shrubs have been planted in camp and project areas. This much has been done by the Soil Conservation Service alone. Other agencies of course, both State and Federal, have done more work along this line and over a longer period.

In the expanded program of the Service now going forward, trees will continue to be a most valuable tool of land-use adjustment—a potent weapon of defense against erosion, floods, and silting—and a means of increasing the productivity of certain farm lands. Over the farm lands of the Nation, there are millions of acres now in cultivation, in pasture, or idle that should have a tree cover both for their own protection and for the benefit of lands, structures, and people farther downstream. Where these lands are a part of related farms or groups of farms, the best practical solution may be purchase and development by some agency of government. But in a majority of cases, submarginal crop and pasture lands can be converted to woods without disturbing the existing pattern of ownership. Usually it can be done with profit if woodlands are established not merely as a stop-gap but as a positive, income-producing part of the whole farm economy.

It is precisely at this point that farm forestry work has its most direct bearing on the basic land-use problem the Soil Conservation Service is helping to solve. The ultimate aim of the new program is to show that forestry on the farm is a paying proposition—to illustrate to farmers that time, money, and effort spent in the farm woods will yield a satisfactory return. Once trees are widely recognized as a crop and treated with proper care, reforestation of unproductive fields and pastures will become a desirable move from every point of view rather than—as it now so often appears—an unwarranted economic sacrifice on the part of the farmer. As land-use adjustment is made easier, its progress over the country will inevitably be accelerated.

In carrying forward the new program, a number of State and Federal agencies will work together to assist the farmer. The State extension services will bring forestry information to the farmer, and help to make the forestry projects effective. State forestry agencies will assist farmers in woodland management and in the production and distribution of planting stock for the projects. The Bureau of Agricultural Economics will take part in the development of State farm forestry programs which eventually will comprise a Nation-wide farm forestry plan. The Forest Service will cooperate in scientific investigations and have departmental responsibility for all projects established in areas where most of the farm income is derived from forest products. The Soil Conservation Service will have similar responsibility for those projects located in areas where timber production is not the dominant factor in the prevailing farm economy.

Projects of this latter type will be called "farm forestry" demonstrations as distinguished from the "forest farming" projects of the Forest Service. Like the forest farming projects, however, they will be selected by a State committee, composed of representatives from each agency taking part in the program, which will be a subcommittee of the State Agricultural Advisory Council.

Once a farm forestry project has been set up, it may differ from the usual erosion control demonstration mainly in that major emphasis will be placed on sound woodland management. In each of these new areas, farm forestry work will have priority over other types of activity, but at the same time farmers will be given an opportunity to obtain the assistance of the Soil Conservation Service in applying conservation measures to their cultivated fields, meadows, and pastures.

From one standpoint, therefore, farm forestry projects may be considered as focal centers not only for proper woodland management but for conservation farming in general. Along with soil conservation districts and water facilities areas, they may become a medium for spreading better land-use practices—for extending over a constantly widening area the type of farm plans that have already proved valuable in erosion control demonstration projects and camps.

But in the new projects a great deal of attention will naturally be centered on the woods. Foresters will go into woodland areas with the farmers and help them in working out long-time plans of protection and management. If woodland management is to be effective, fences will need to be erected to keep out browsing, trampling livestock. Firebreaks and trails may be needed to guard against the danger of uncontrolled flames. Deliberate burning of underbrush will need to be discouraged. Scientific thinning will be recommended. Dead or inferior trees will have to be removed, and open areas spot-planted to build up gradually a well spaced and healthy stand.

In addition to timber stand improvement work the program on each individual farm will include a careful schedule of cutting. The farmer will know in advance just which trees to harvest in any year and which ones to leave as capital growing stock. By observing well established forestry principles, he will be able to draw out annual "interest" in the form of a crop of timber and still maintain his "principal" intact.

Remarkable growth in 7½ months of black locust planting on badly eroded old corn field in Nacogdoches soil.

Everything possible will be done to keep young and vigorous trees coming along all the time—to preserve the woods as a reliable asset with the highest possible value.

To the individual farmer taking part in the program, farm forestry work should bring direct and tangible benefits. In addition to better protection for the soil, it should mean a more valuable supply of timber for home use or for sale. Today, with the demand for many wood products constantly expanding, with synthetic fibers assuming a growing degree of importance in our national economy the prospects of financial return for work in the woodlands are perhaps better than ever before. Of course, there are few fortunes to be made from farm forests, but there is a welcome source of supplemental income in practically all well managed ones. And in times of crop failure, a productive woodland may well provide the cash necessary to tide the family through. In any event well managed woodlands should contribute definitely toward greater stability of farm life.

The main significance of the farm forestry projects, however, will lie in their demonstrational value. By helping farmers in a few representative areas to improve their woodlands and develop better methods of management, the demonstrations should start thousands of farmers outside the projects thinking in forestry terms. Since the results of woodland management are not always readily visible, a considerable amount of emphasis will be placed on the keeping of records. Every farmer cooperating in the program will maintain a careful account of his woods—of cash expenditures and cash receipts, of labor devoted to woodland improvement and products harvested for home use. Over the years, it is expected that most of these farmers will build up an impressive case in favor of sound use of woodland on the farm.

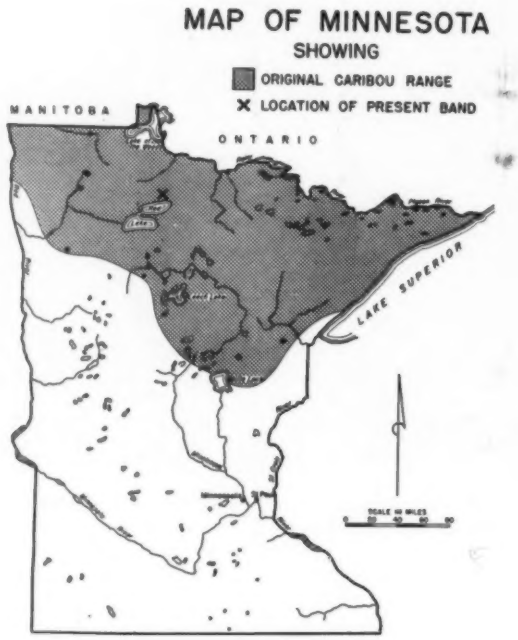
As woodland management begins to assume a more important position in the agriculture of this country, widespread benefits are almost sure to follow. Many idle and run-down lands will be rehabilitated and put to productive use. Source areas for floods and silting will be covered with a soil-protecting, water-absorbing growth of trees and shrubs. Living conditions for wildlife will be greatly improved. With the returns from well-managed woodlands helping to round out the farm income, many farmers will be better able to make improvements and practice conservation over the farm as a whole. In some sections, the reliance on soil-depleting cash crops will be lessened, and the desirable trend toward greater diversification will be intensified.

But all these things, of course, lie in the more or less distant future. Right now the Soil Conservation Service and the other agencies taking part in the farm forestry program face a large-scale job of education,

(*Continued on p. 163*)

WOODLAND CARIBOU IN MINNESOTA

By WILLIAM T. COX [1]



PERSONS interested in wildlife know well the tragic stories of the passenger pigeon and the heath hen. Not so many years ago heath hens abounded in the New England States, and passenger pigeons were so numerous in the Mississippi Valley that their flight sometimes completely obscured the light of the sun. Today, both species of birds are extinct—destroyed by a wave of remorseless slaughter that will remain always a blot on the sportsmanship of the white man.

But until a few years ago, not many people were aware that a similar fate imminently threatened one of the finest species of big game in the United States: the woodland caribou (*Rangifer caribou-sylvestris*), closely resembling the reindeer of Lapland, has been approaching extinction; the species had in fact almost reached the vanishing point in the United States before anything was done to save it.

Northern Maine and the northern one-third of Minnesota were the original caribou ranges within the United States. At one time from 3,000 to 5,000 animals ranged in Maine, and from 5,000 to 10,000 in Minnesota. The species is believed to have disappeared from Maine over 20 years ago, and only three of the native animals remained in Minnesota before the time of the expedition with which this article is concerned. Even in Canada, where the species was plentiful until recently, woodland caribou have become scarce. The letters that I received from the game guardians of the Provinces indicate that New Brunswick no longer has any caribou, and that the animal is extremely rare in Quebec and Ontario. Although large numbers existed in Manitoba a few years ago, only a few animals now remain in that Province.

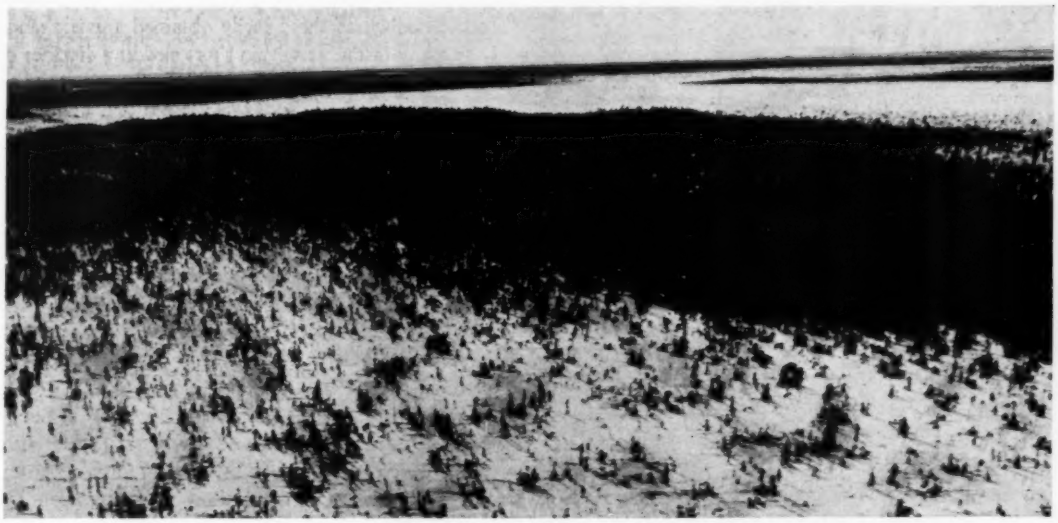
Northern Saskatchewan and Alberta are the only Canadian Provinces where fair numbers persist, although Newfoundland still has a good many woodland caribou. There are, of course, large numbers of the barren ground caribou (another species) in the country east of Lake Athabaska and Great Slave Lake; and there are also numbers of mountain caribou of several kinds in British Columbia and Alaska, but the woodland caribou is far on its road to extinction.

When the white settlers came to Minnesota, the State was a close approach to the "happy hunting ground" of Chippewa and Sioux and Cree. Deer were abundant in the southeastern counties, buffalo and antelope roamed the prairies, elk ranged in the "Big Woods" and along the border line of prairie and forest. Moose wandered through the timbered swamps, and woodland caribou, then a populous animal, ranged over the more open bog country.

The sparse Indian population, possessing only inferior weapons, was unable to take any considerable toll of the big game herds. But with the advent of the white hunter the mortality rate of all big game soon greatly exceeded the birth rate. Some species—the buffalo and antelope, for example—quickly disappeared from the State. By 1900, practically all the elk were gone and the caribou were to be found in only a few spots, and there in very small numbers.

It was while I was on a snowshoe and dog team trip through the country north of Red Lake, Minn., in 1913, that it occurred to me that we Minnesotans should make an effort to perpetuate the elk and caribou as part of the native fauna of our State. I therefore asked the legislature to appropriate $5,000, for use in obtaining elk from the Rocky Mountains and building a 700-acre enclosure in Itasca Park and Forest within

[1] Assistant regional biologist, Upper Mississippi Region, Soil Conservation Service, Milwaukee, Wis.



Air view of the black spruce "island" where the last three native woodland caribou in Minnesota over-wintered in 1935 and 1936. The spruce trees are covered with a lichen that serves as winter food for the animals.

which the elk could be given careful protection. The money was provided, the fence built, and the elk obtained. They gradually increased in number and are now well established in a number of places in northern Minnesota.

It was on that same snowshoe trip that I first saw the Red Lake band of caribou, ranging between Red Lake and the Rainy River. There were at that time only 33 animals in the band, and they were feeding in an open swamp or muskeg where occasional clumps of black spruce and tamarack gave partial protection. During the few years prior to my trip there had been a great reduction in caribou numbers, if one may judge from seemingly authentic reports of the number taken out of this locality by Red Lake Indians and by professional hunters who sold the meat in the Red River Valley.

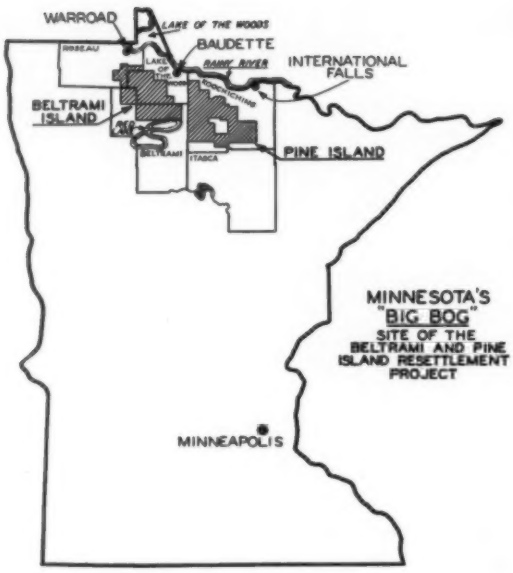
The bands in Aitkin County, and in Cass, Itasca, St. Louis, Lake, and Cook Counties had already disappeared, except for an occasional individual found around Vermillion Lake and in Cook County, and these stragglers were gone soon thereafter.

For a number of years, we in Minnesota encouraged the forest rangers and game wardens to do the best they could to protect the Red Lake band of caribou, but with little success. In 1924, while making an airplane reconnaissance of the timber and wildlife resources of the region between Lake Winnipeg and Hudson Bay, I saw a good deal of the Canadian caribou country. A few months later, in discussing the wildlife of that territory with Dr. E. W. Nelson, then chief of the Bureau of Biological Survey, I suggested to him that woodland caribou for replenishing the Red Lake band in Minnesota be obtained in the Lake Winnipeg district where they were then fairly abundant. Doctor Nelson expressed keen interest in the proposal, but a shortage of funds at the time made it impossible for the Bureau to undertake the capture and importation of the animals.

In 1932, when I was State Commissioner of Conservation in Minnesota, I issued an order establishing the Red Lake Wildlife Refuge of 480,000 acres, with the definite objective of preserving the caribou and other big game in that district. The moose, deer, and beavers increased as a result of the protection afforded by the refuge, but the caribou population continued to decline.

Why the decline?

A number of factors were responsible. I have mentioned the inroads made by hunters, which may or may not have been the chief cause of reduction in caribou populations. Another factor, of perhaps equal importance, was the extensive drainage work done in the "Big Bog" area of northern Minnesota between 1909 and 1922. Hundreds of miles of ditches were dug, and the wet swamps were converted into vast areas of highly inflammable peat lands covered with grass and brush interspersed with cedar and spruce forest. Fires raged through the country year after year, despite strong efforts to control. Many people burned to death, and the toll of wildlife was tremendous. Undoubtedly large numbers of caribou perished in these fires.



The drainage ditches, where they crossed actual muskeg area, were themselves veritable traps for big game. They varied from 6 to 8 feet in depth, were so soft on the bottom that large animals were mired in them, and their banks were steep and high. Rangers often found dead animals in them.

The lowering of the water table, brought about by the drainage program, was another factor tending to reduce caribou populations. Before drainage work was started the cows could find little islands far out in the wet swamp where they could drop their calves comparatively free from molestation by wolves. After the swamps were drained, the wolves could pick up the calves readily without the necessity of swimming or wading to the islands.

Disease and parasites may have been factors influencing the population declines. The fact that in the same territory moose have suffered serious losses through these causes leads one to the conclusion that caribou were also affected, in all probability.

With reference to the rapid decline in the numbers of woodland caribou in Canada, it is of interest to note that Indian reservations in that country are small and numerous. Every 5 or 10 miles through the forest country one finds a few Indian families occupying a tiny "reservation." This system of scattering the Indians works out well insofar as harvesting the fur crop is concerned but it is anything but favorable to the caribou as these easily obtained animals range in so many instances within short sledding distance of the Indian habitations. Since the caribou is easier to get than moose, and about as palatable, it is hunted by the Indians as a source of winter meat.

The Indians, however, are by no means the only threat to the Canadian woodland caribou. Recent years have seen widespread prospecting and mining activity in the wild portions of Manitoba, Ontario, and Quebec; and, as might be expected, large numbers of caribou have furnished food for the prospectors' camps. For 2,000 miles across the continent, from New Brunswick to Saskatchewan, the future looks gloomy indeed for the woodland caribou. Only through intelligent and persistent effort will it be possible to save this splendid animal from extermination. Sanctuaries must be established in places naturally favorable to caribou; thorough protection and intelligent environmental control will be needed. With regard to environment, it should be pointed out that the woodland caribou is "choosy" in its food habits; it needs a variety of browse and moss not found everywhere in the forest country.

The initiation of the Beltrami resettlement project in 1935 seemed to me to offer an unusual opportunity for doing something worthwhile toward reestablishing the caribou in the United States. The project, transferred to the Soil Conservation Service in the fall of 1938, includes the Red Lake wildlife refuge and some 320,000 acres besides. The removal of the scattered and stranded settlers from this territory and their relocation on better land has reduced the losses to big game caused by poaching. Fire hazards have been greatly reduced, not only by removal of settlers but through the blocking of hundreds of miles of useless drainage ditches; the latter has restored marsh conditions and made the area highly productive of wildlife—the soundest land use for this particular territory.

The factors believed to have been largely responsible for the decline of the woodland caribou, and moose also, have been largely removed, and with the completion of the project's development program conditions should be favorable to an increase in all big game, including caribou. In addition, the largest wild-fowl and the best beaver area in the United States has been created and is now functioning so well that it is listed among the "top-notch" wildlife refuges of the country.

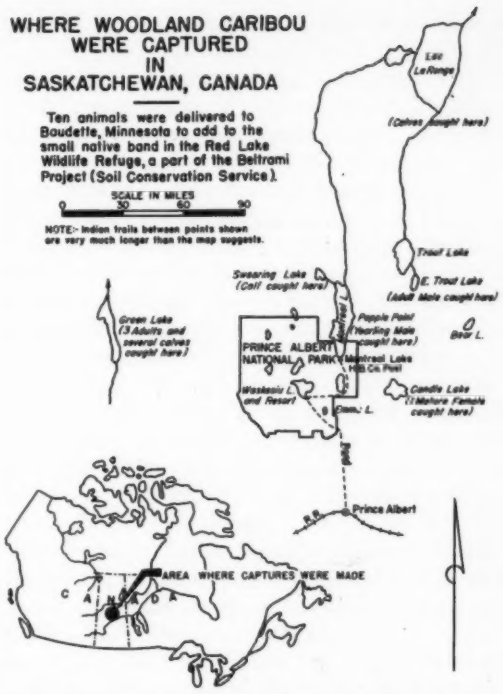
But even after the project was begun, and the wildlife possibilities inherent in its development became clear, the outlook for Minnesota's caribou band seemed dark indeed. The three animals composing Minnesota's band were all cows.

Therefore, I began making plans for restocking the Minnesota range with animals captured in Canada. First of all came the problem of learning enough about caribou range and food habits to ensure a fair measure of success in the proposed venture. It was surprising how little was actually known about the range needs of the woodland caribou, the foods they eat and their general habits. Accordingly, I asked Jack Manweiler, game manager for the Beltrami project, to make a study of the habits and food requirements of the caribou in the Beltrami area.

Manweiler's survey was begun in January 1936 and, believe me, it was no job for a tenderfoot. It was necessary to trail the caribou at all seasons of the year over difficult terrain, and to suffer from severe cold in winter and the severe punishment of insects in the summer. But the job was done, and well done. Manweiler's information has since proved invaluable in the feeding and general care of the captured caribou.

Some of the details of the Manweiler survey are of exceptional human interest. For example, there is the story of the first trip of the group conducting the caribou study—in January 1936. A party of four persons, including Manweiler, two assistant wildlife specialists, and a State trapper left the highway at 5 o'clock one morning with a dog team of seven animals drawing a toboggan carrying food and equipment weighing 400 pounds.

But it is better that the remainder of the story be told in Manweiler's own words: "The snow was deep, making it necessary to beat a trail for the dogs for the


WHERE WOODLAND CARIBOU WERE CAPTURED IN SASKATCHEWAN, CANADA
Ten animals were delivered to Baudette, Minnesota to add to the small native band in the Red Lake Wildlife Refuge, a part of the Beltrami Project (Soil Conservation Service).
SCALE IN MILES
0 50 60 90
NOTE:- Indian trails between points shown are very much longer than the map suggests.
Lac La Ronge
(Calves caught here)
Trout Lake
E. Trout Lake
(Adult Male caught here)
Swearing Lake
(Calf caught here)
Green Lake
(3 Adults and several calves caught here)
Peppin Point
(Yearling Male caught here)
Bear L.
PRINCE ALBERT NATIONAL PARK
Admiral Lake
Wassaisy L. and Resort
Candle Lake
(1 Mature Female caught here)
Prince Albert
AREA WHERE CAPTURES WERE MADE

entire distance of 14 miles to the first shelter. As the day progressed, the storm turned into a blizzard with a maximum low of –50°. We attempted to follow a ditch grade rather than the open bog because potholes and ditches were filled with drifting snow which

Manweiler and 6 of the captured calves, in June 1938, a few weeks after the trapping expedition which netted 10 caribou for use in restocking Minnesota's "big bog." The calves then averaged 30 pounds each and were kept in a fly-proof enclosure.

192705—39——2

served as an insulation and kept the water underneath from freezing. Even with snowshoes, a step into one of these holes would have proved disastrous, because we should have been unable to secure firewood from the sparse bog vegetation and so could not have dried out clothing.

"The deep snow proved too much for the dog team and it was necessary to leave two of the animals which although they courageously tried to pull their share of the load became paralyzed in the hind quarters. These dogs burrowed into the snow and were rescued 2 days later, when they were found to have no serious injuries; the animals were accustomed to sleeping out of doors and receiving only one meal a day. By 4 o'clock in the afternoon, the party had progressed approximately halfway to our proposed destination—a shelter cabin on a bog pond several hundred feet in diameter and known as Hillman Lake. We stopped for the first rest period of the day and ate a meal of hardtack. Darkness began to fall and the blizzard became more menacing. It was impossible to remain in the open bog for the night, so the journey was resumed.

"While we were crossing an open stretch in the darkness, we lost the ditch grade and an anxious consultation was held at once to decide what our future actions should be. We determined to go with the wind, which was generally from the north, in the hope of finding an island of green timber for protection. Within a comparatively short distance, however, the ditch grade was again located and the journey toward the shelter cabin was resumed.

"By this time, members of the party were helping the dogs pull the load. It is probable that this labor helped save our lives, by maintaining sufficient body temperature. When we closed our eyes against the stinging snow particles, the eyelashes often froze together, making it necessary to thaw them out by applying our bare hands which, of course, soon became numb from exposure.

"By 2 o'clock in the morning—21 hours after we started our trip—we realized that our objective, the shelter cabin, had been passed in the darkness and that it would be necessary to go back through the storm to find it. It was sheer luck that enabled us to locate Hillman Lake and the cabin—22 hours after leaving the highway.

"Luckily shavings and a small amount of firewood had been left in the cabin during an earlier trip—foresight which undoubtedly saved our lives. But there arose the almost unbelievable obstacle of our inability to hold and light a match. After many efforts, we finally ignited a handful of matches and started a fire. Next came the painful job of thawing out. Two hours after our arrival, our socks were still frozen to our boot soles. By daylight, our ears were the size of hens' eggs and we were forced to lance them and apply kerosene to ease the pain.

"Reward for our suffering came almost at once, however. The following morning we sighted the caribou within one-half mile of the cabin—a piece of luck which relieved us of the necessity for many days of search.

"The only other problem at the time was that of finding in the scattered black-spruce swamp sufficient firewood to keep us warm. One week later, when we returned to headquarters, our faces were still splotched with black, frozen skin."

Certainly no job for a tenderfoot!

But I'm sure Manweiler agrees with me that the sacrifices made during the caribou food-and-habit study were more than balanced by the amount of new and useful information obtained. Plans for capture and importation of the caribou were completed.

I found that the only Canadian Province where conditions seemed to justify the taking of caribou for stocking purposes and where a permit to get them could be obtained was Saskatchewan. That Province authorized us to take 10 of the animals—*if we could catch them*. There was a "catch" in the business, both literally and figuratively. However, the United States Department of Agriculture was persuaded to provide the money to pay for the capture and transportation. The State of Minnesota and the Bureau of Biological Survey cooperated, and we finally started field operations about 100 miles north of Prince Albert, Saskatchewan. There the Hudson Bay Co. had generously consented to act as our agent to interest the Indians at Montreal Lake Post in a prolonged caribou hunt to obtain the animals for us.

This was an exceedingly difficult task, much more difficult than catching live moose, elk, or deer. It was necessary that Manweiler go up to Prince Albert and the Hudson Bay Post at Montreal Lake to supervise the taking of the animals, and to see that they were properly fed and cared for afterward. Also, his presence at the post was found to be almost essential to keep Indians out on the hunt, as the caribou were in small bands scattered throughout a large and difficult district.

The work was most discouraging at first. It yielded success later, however, when technique and equipment were improved. But again it is best to hear the story in Mr. Manweiler's own words:

"On March 16 I left Baudette, Minn., for Prince

Albert, Saskatchewan, where a plane was obtained for the remainder of the trip to Hudson Bay Post on Montreal Lake. At the lake, every available convenience was placed at my disposal by the post manager. Meetings with the Indian chief, his counselors, and those trappers who were known to be reliable were immediately held to induce them to take up trapping operations. This was a difficult matter, as the trappers and the Indians were of the opinion that adult caribou could not be taken without injury. Furthermore, no provision had been made to defray grubstake expenses, and the Indians because of their low finances could not begin operations until I had made arrangements to supply food, rope, and other essentials.

"Several days later, the first trapping party, equipped with a week's supply of food, rope, snares, dog teams, etc., established headquarters on the north shore of Montreal Lake, about 35 miles from the post. During that first week no evidence of caribou was discovered. Their disappearance was explained by the fact that extensive fires throughout the preceding summer had caused the animals to avoid their usual haunts; that heavy inroads of timber wolves tended to drive them from the country; and that the mild winter was not conducive to mass migration and concentration.

"Our failure to discover any signs of caribou was disheartening and increased greatly the difficulty of getting additional trapping parties to make an attempt. New territories were explored and fresh signs discovered. New trappers were provided with snares, and additional attempts were made to capture animals. After two of the trappers returned to the base camp, having taken two caribou in snares set at an earlier date, more trappers became interested in the work. Although the first three animals taken escaped, a spirit of optimism developed which, with the assistance of the post factor, was carried through to the end of operations. It was, of course, still necessary to supply rations and rope to all field parties.

"Use of a pitfall to capture animals was entirely unsuccessful; it was necessary to build such pits on caribou trails, where it was difficult to camouflage effectively; and in swampy country water stood a foot or so beneath the moss so that construction of pits was impracticable.

"Rope snares proved the most successful devices for capturing carbou. We were careful to make the snares strong enough to hold the animals, and to design them in such a way that animals would not be likely to become strangled. The first snares set were constructed of ordinary clothesline type of rope, saturated with mucilage. Mucilage was used to "cover up" the rope smell, which would otherwise have frightened away the animals, and to give a smooth surface and so protect the captured animals against rope burns. The choice of mucilage for this purpose, however, proved unfortunate. The first animal captured developed an unaccountable taste for this substance and nibbled at the rope until he was free.

"The rope used in later snares was boiled in a mixture of spruce and cedar boughs and then coated with paraffin. It was necessary to change the location of snares several times during the period of trapping to meet changing snow and water conditions in the peat bogs and highland regions. Though the hunt was continued until June, no attempt was made to capture animals swimming in lakes after ice thawed. Such captures probably could be made quite easily as caribou are often seen swimming and can be approached by canoe.

"All in all, 18 adult caribou were taken in snares. Three of them were released either because trappers misunderstood the sexes desired or were afraid of the enraged animals. Eleven animals escaped. Four adults were finally brought to Montreal Lake headquarters. Two of the four adults died, one from injuries caused by a trapper's dog which preceded the trapper to the snare, and the other from the results of improper handling on the part of the trappers.

"Work was continued through June and eventually 10 animals were taken, 8 of them calves. These were transported by truck from Montreal Lake to Prince Albert, by express to Baudette, and then by truck 35 miles to Ludlow Island in the Beltrami project. There, the animals were placed in a corral and quickly became reconciled to their new surroundings. One of the eight calves died, but the remaining seven are doing well. Each calf weighed approximately 22 pounds when captured. The calves now average approximately 200 pounds and are in fine condition.

"The largest animal captured, a male weighing 350 pounds, was kept in the corral only 6 months. At the end of that time, he was transported by a caterpillar tractor through 12 miles of bog and released in an enclosure covering 4 square miles of bog land and constructed of a seven-strand barbed wire fence 7 feet high. He was allowed to range there until the first part of October, at which time he was liberated to join the three native cows that were in the immediate vicinity. The last sign of this animal was noted in February 1939, nearly a year after the date of capture. At that time, he was ranging with the native cows.

(*Continued on p. 156*)

SNOW SURVEYING

By JAMES C. MARR [1] and PAUL A. EWING [2]

Removing snow-sampling apparatus from canvas carrying case preparatory to use. (Photo courtesy U. S. Forest Service.)

SNOW is water, and water is wealth.

These are axioms in the West, where most of the year's precipitation falls in the winter months and the summers are dry. Western farmers, great cities and the corporations that manufacture electric energy through the medium of falling water, all watch the accumulation of snow high in the Rockies, the Cascades and the Sierras, quite as jealously as they scan their bank or treasury balances, even though the snow itself may be hundreds of miles away. Indeed, if those distant snow deposits are low when spring is at hand, bank balances are pretty sure to suffer too, before the summer ends. But when "at the summit" great depths of snow are reported in late winter, the West is optimistic, for then the long dry summer holds no serious threat of drought. Its heat will melt the treasured snow and abundant water will come down from the mountains.

When will it come? How much will there be? It is easy to say that the snow falling at this very moment on some high watershed presently will become a natural storage reservoir from which some low fertile valley will derive its summer water. It is not yet possible to say just when, just what amount; but while the amount of run-off from a watershed cannot be predicted merely from meteorological measurements of the snow that falls, dependable forecasts of seasonal run-off can be made from measurements of the snow pack after the accumulation of snow has reached its maximum. For more than 30 years such forecasts have been made on the data obtained from measurements of the water content of winter accumulations of snow. The accepted method of making these measurements is termed "snow surveying."

Up to 1935 successful forecasts based on snow surveys were made for most of the principal watersheds in Nevada, Utah, and California. Some forecasting was done also in Oregon, Idaho, Wyoming, and Washington. In later years, since July 1, 1935, there has been under way a program authorized by the Federal Government to extend and unify the activity throughout the 11 Western States. The services of a large force of about 2,000 responsible and experienced men are needed to make the surveys simultaneously at widely separated points over a vast region at designated times during the winter months. Many of these observers are employees of various Federal, State, and municipal agencies, power companies, and irrigation enterprises without whose cooperation the work could not be carried out successfully on so large a scale.

The procedure for determining the water content of snow consists essentially in procuring cores of small diameter, vertically, from the snow cover at the designated points along a snow course and weighing them. A metal tube, designed especially for the purpose, is used to obtain the cores. The diameter of the snow core is such that its weight in ounces is equivalent to inches of water; that is, a core of snow weighing 1 ounce represents 1 inch of water in a cylinder of the same diameter. Thus snow depth is quickly and accurately converted into the more significant figure, water depth, simply by weighing the cores, and a measurement made in this manner discloses the depth of water in the snow mantle at a properly located sampling point.

The accuracy and rapidity with which the water-content measurement is made with standard snow-sampling equipment gives this procedure a practical advantage over other known methods of making such measurements, particularly when the measurement must be made in the high, isolated mountain areas during the winter.

Obviously, it is difficult from observations of snow depth made in snow-stake recordings to estimate ac-

There are now more than 7,000 farms—approximately 2,000,000 acres—cooperating with soil conservation districts in fighting erosion. These farms are scattered through 116 districts in 23 states.

[1] Irrigation engineer, Soil Conservation Service, Boise, Idaho.
[2] Irrigation economist, Soil Conservation Service, Berkeley, Calif.

curately the water content of the snow cover, especially when it is deep and laminated, and the observed depth of snow alone is inadequate as a basis for forecasting run-off.

The arduous and time-consuming practice of gathering samples of the snow cover and melting them to determine water content is also made unnecessary by the quicker, easier, and more accurate way in which the measurements are obtained with standard snow-sampling equipment.

If a reliable forecast is to be made from the measurement of the water content of the snow, certain requirements must be observed:

1. *Measurements must be made at elevations where little or no melting occurs until after April 1.*—The snow surveyor may have to travel far into the mountains to reach elevations where snow will not have melted materially by the time of the April survey. There are other reasons also for placing snow courses high in the mountains, but this one alone justifies the difficult winter trips sometimes required to reach these elevations.

2. *The snow course must be sufficiently accessible to insure continuity of the surveys.*—Great care should be exercised in finding the most accessible location when a snow course is established, especially if it is a high one. If after a course has been established another location just as good is found, it is not advisable to change the location because the change destroys the continuity of the records on which the forecasting is based.

3. *Measurements must be made at a sufficient number of fixed points on an established, marked course to insure that the average of such measurements will not be unduly affected by drifting or wind-swept snow.*—Snow surveyors find little similarity in the design of snow courses, and many wonder why some are longer and call for more measurements than others. Each course is planned definitely to permit a group of measurements, the average of which will represent the snow cover at the given elevation and exposure. The topography and the presence or absence of forest cover account for wide variations in the design of courses.

For example, an open place may be found in the forest, nestled among hills and protected from high winds, and large enough so that snow may fall to the ground without being intercepted. If the snow falls and lies uniformly over this area, a few measurements, made either as a group in one open space or separately in several adjacent open spaces, will yield the desired record. If the open space is large and of a shape that might permit the snow to shift within it, the only sure plan to follow is to make a series of measurements along lines that form a cross or an ell or otherwise so arranged that the average of the measurements will represent the snow cover within the area.

If protection from wind is altogether lacking and the course must be in the open, the measurements should be taken over an area of at least one-half square mile. A small area cannot be selected with assurance that the average of any number of measurements made within it will indicate the average snow cover for the locality. Since sufficient knowledge of the tendency of the snow to drift if unobstructed and the direction in which drifting will occur is lacking, it is expedient to provide for an extensive survey having long courses and a large number of snow measurements. Once the prevailing length and direction of snow drift has been ascertained it may be possible to shorten these courses, but probably they will always have to be relatively long and many snow measurements will have to be made.

4. *Surveys must be made on a sufficient number of courses properly located on each watershed to cover the variability of storms over the watershed.*—A snow survey should show the amount of snowfall accumulated during the preceding winter months. It is important therefore that surveys be made at the time of year marked by termination of winter storms, because not until then can there be assurance that the snow mantle has reached a maximum for the year, nor can the final and most important forecasts of the year be made.

The general program in the Western States calls for a survey about the 1st day of each month from January to May, inclusive, on a limited number of key courses and surveys at all courses on March 1 and April 1. If a survey can be made on only one of these dates, April 1 is preferred. The schedule is thus ordered particularly to make possible the regular water-supply forecast service, required for efficient operation of irrigation projects, municipal water works, and hydroelectric plants. It is more than adequate to serve other purposes as well, except for the need of the northwest coastal section to know snow conditions throughout the winter so that its typically erratic winter floods may be guarded against. A schedule for this coastal section has not yet been adopted.

While the most important date in this schedule is the time of the year marked by the termination of winter storms, this date actually varies somewhat from place to place and from year to year. It may be March 1, April 1, or some intervening date. It has been impossible to fix a date that all snow surveyors

Shelter cabin with tower ("Santa Claus chimney") to permit entrance when cabin is buried under deep snow.

will recognize as best for their sections as well as proper for a large region such as the Columbia River Basin.

Furthermore, the forecast service, like the surveys, must follow a rigorous time schedule. Actually, only timeliness is sacrificed by fixing April 1 as the date when the surveys are made on all courses and when the final and most important forecasts of the year are announced. If the courses are properly located, the snow lying on them the first of April will still represent the winter's maximum snow mantle in water content, even though snow at lower elevations has melted to some extent and some run-off has already occurred. At least there may be assurance at this time that the winter storm period is practically over and that the movement of the snow will be very near to the maximum for the year. Nevertheless, meteorological developments may prove that forecasts as of April 1 might have been made with equal accuracy 1, 2, or 3 weeks earlier, and since there is need for this information as early as it is obtainable, the March 1 surveys have considerable value. As a basis of tentative forecasts they should be as complete as possible for all courses.

Less effort to procure complete information in making snow surveys on January 1, February 1, and May 1 is usually warranted. One key course on each important tributary of a major drainage basin may yield satisfactory data, but measurements are taken on more courses if the cost and effort required are small. They are useful as a means of following developments in water-supply conditions throughout the winter and early spring months. January 1 surveys are relatively least important and may be omitted if a long trip is required and soft snow makes travel difficult. May 1 surveys are particularly useful because they indicate prospects for late-season run-off.

Though the 1st day of the month is specified for making the surveys, a reasonable variation is permissible and frequently necessary; hence a period of 4 days before and 4 days after the 1st of the month (8 days) is prescribed as that within which the surveys should be made. If difficult travel into high country is required, it is expedient to take advantage of cold-fair weather for the trip. It is better that these data be procured several days before rather than after the 1st of the month to insure their prompt publication and use.

Locally there may at times appear to be little need for a survey, but always somewhere downstream are conditions that make maintenance of the time schedule necessary.

Water-supply forecasts based on snow surveys are made on the assumption that there is a simple relationship between the water content of the snow cover of a watershed and the run-off from the watershed. Such forecasts can be made more simply and accurately if the major part of the precipitation occurs as snow at high altitudes, where there is little or no melting. For any watershed for which dependables snow-survey data and run-off data are available representing several consecutive years, a chart can be designed from which an estimate of the run-off, for a determined storage of water in snow, can be made. Such a curve will, of course, apply only to the watershed from which the data were secured and should be recalculated as the observations become available.

The desirability of making the maximum use of water in irrigation, and the variation in the amount available from year to year, call for water-supply forecasting. An accurate forecast guides farmers in planting their crops and permits efficient operation of irrigation works.

Snow-survey data indicate the probability of floods. Other factors, such as temperature variation from normal and occurrence of heavy rainfall, must be considered with snow-cover conditions in predicting when floods will take place and the heights to which the water will rise. The River and Floods Division of the United States Weather Bureau, the Corps of Army Engineers, and other governmental units similarly concerned with floods are promptly supplied with all snow-survey data. If the accumulated snow cover is determined to represent a potential flood hazard and reservoir capacity is available, immediate steps may be taken to prevent possible disaster by operating the reservoirs as flood-control works. In most cases the reservoirs are used to store water for irrigation, power, and water-supply purposes, which require that they be filled during the spring run-off period. Water-supply

forecasts based on snow surveys make it safe, however, to use them to good effect as flood-control works, with assurance that they will fill.

Many power companies have long employed snow surveys to obtain indicators of stream flow on which to base operation schedules. The procedure is especially necessary where water is used for both irrigation and generation of electric power. For instance, at Boulder Dam the economy of generating as much firm power as possible on a continuous basis and at the same time retaining enough water for irrigation makes it necessary to know in advance how much water the mountain snow cover will yield.

Much importance is attached to snow-cover data, particularly by the United States Forest Service, as an indicator of forest fire hazards and grazing conditions. Prolonged drought increases the danger of disastrous forest fires and diminishes feed for livestock and wildlife on the range. Any indications that forests will be dry afford an opportunity to put into effect measures that aid in preventing and controlling fire and in avoiding the overstocking of the range.

Water is so scarce at times on some range land that the flow of springs is the factor limiting the use that may be made of the feed. Correlation of the past performance with snow-cover data afford a proper basis for granting grazing privileges.

Cities such as Los Angeles and Denver, which depend upon storage, stream flow, or springs for water, are benefited by and rely confidently on forecasts based on snow surveys.

The ease with which snow densities may be ascertained with standard snow-sampling equipment has prompted its use for determining the snow load that structures must be designed to withstand, and density measurements are being made with snow-sampling equipment in order that power necessary to open snow-bound roads may be gaged accurately.

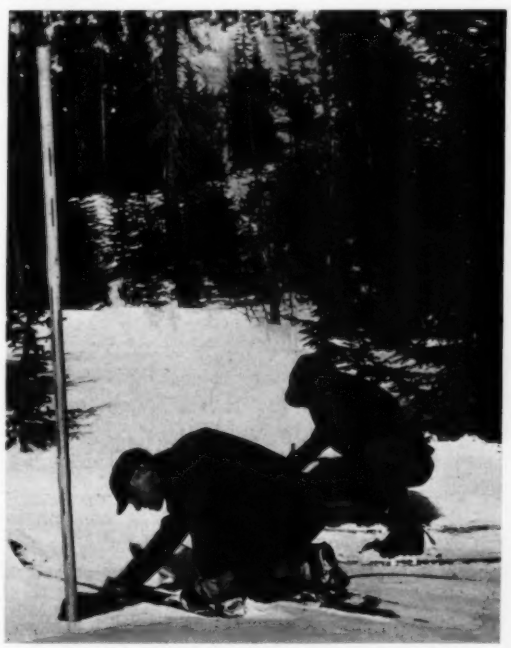
The Federal land banks and similar credit agencies study the forecasts in order to restrain or encourage farm operations that may affect the ability of farmers to meet their financial obligations.

The Federal Crop Reporting Service, and other agencies concerned with statistics relating to crop production, use snow-survey measurements as indicators of the types of crops that will be planted on irrigated land and of prospective harvests. Promise of an ample supply of late water leads to the planting of late maturing crops, whereas only early maturing crops will be grown if it is known that the water supply will be short, especially during the late growing season. Moreover, the amount of water to be available is the major factor limiting crop yields. Thus irrigation water-supply forecasting is helpful in predicting not only unit yields but also the acreages of various crops.

The water supply is frequently a chief concern in planning the operations of mines, especially placers, and in smelter operations; data obtained in the snow surveys are accordingly of considerable use to the mining industry.

The Migratory Waterfowl Division of the United States Biological Survey maintains numerous inundated areas throughout the West as feeding grounds and refuges for wildlife. Elaborate systems of dikes and diversions have been required for regulating the depths of water and for extending or restricting most of the flooded areas in accordance with amount of water available. Water-supply forecasts based on snow surveys are useful in effecting the best operation of these systems.

In brief, the water-supply outlook is of general interest throughout the West because people interested in production, trade, shipping, banking, and employment all follow the water-supply trend somewhat closely. In an article to appear in a later issue of SOIL CONSERVATION, the authors expect to describe the manner in which the field work of snow surveying is conducted, the apparatus used, and some of the problems the men engaged in the work have to face and overcome.



Snow surveyor reading depth of snow on snow tube scale.

FACTORS AFFECTING RUN-OFF FORECASTS BASED ON SNOW SURVEYS[1]

By W. W. McLAUGHLIN [2]

WATER-SUPPLY forecasting, by means of snow surveys, is a relatively recent engineering development in the field of soil and water conservation and use.

Snow surveys consist essentially of measuring the amount of water held in storage as snow on the ground at permanent locations on mountain watersheds. They are the universally recognized bases for estimating the water potentialities of mountain snowcover.

Snow surveying for water-supply forecasting is practiced, perhaps most importantly, in the arid and semiarid country lying westward of the Mississippi River. Its adaptation to water-supply forecasting was initiated here more than 30 years ago. Since then it has been perfected and its utility for the purpose proved to the point where it is generally conceded to be the best means for forecasting water supplies in this region, where climate and topography make an ideal setting for demonstrating the utility of snow surveying. For the most part the climate ranges from arid to semiarid. It is further characterized by a dry season which coincides with the growing season. The topography comprises broad valleys and high mountains. In the valleys lie the principal opportunities for human occupation with the exception of limitations imposed by dearth of water. The mountains yield practically all the water. Upon them falls as snow during the winter season the greater portion of the meager annual precipitation of the region. At elevations ranging from 3,000 to 12,000 feet the snow accumulates to depths of 4 to 20 feet or more by spring. With commencement of the dry season and subsequently, this snow melts and feeds needed water directly and through the ground into the water courses. The irrigation of nearly 20,000,000 acres of land depends upon this water as does the operation of huge hydroelectric plants. It is important to know how much water will be available for these and other purposes. Obviously the setup favors looking for this information in the mountain snow pack.

It might appear that water-supply forecasting in this case would be a simple matter of following the precipitation trends and judging water prospects accordingly. We know by experience, however, that ordinary meteorological data and methods do not serve our purpose well enough. The intervening time between the occurrence of precipitation and the appearance of flowing water antiquates snow and rainfall data too much. Profound changes in amount and form of the water precipitated and in watershed conditions take place during this interim. We have found it necessary instead to determine the characteristics of the ultimate snow pack and to take into account the final condition of the watershed. This is an imposing engineering undertaking involving the use of especially devised instruments and technic, difficult field work, and the services of an army of trained snow surveyors.

However, the course method of snow surveying is not an attempt to determine quantitatively the actual amount of water stored on any particular watershed in the form of snow, but rather to establish the relation between the snow cover at certain definite locations and subsequent stream run-off from the watershed, not alone for the season but by semimonthly intervals during summer and fall. The utility of the method lies in the fact that most of the winter's effective snowfall occurs in a few heavy storms which usually are uniform in intensity over large watersheds. Thus a relatively few properly placed courses will accurately reflect the watershed snow cover in comparison with the cover of previous years. It may be assumed, all other conditions being equal, that there is a definite determinable but not direct relation between the water content of the snow as measured on the courses and the subsequent run-off. The method becomes more accurate with each year's additional snowfall and run-off records. Such correlations may be attempted after 3 years of records are secured, but will show more promise of success if delayed until at least 5 years' records have accumulated.

In the simple case, unaffected by disturbing factors to be discussed later, the relation may be shown conveniently and clearly by plotting the snow-water content of the final spring survey (usually taken about April 1) each year as an ordinate with the corresponding resultant run-off as an abscissa. A smooth curve (often nearly a straight line) may then be fitted to the data either by eye or by the method of least squares and used in forecasting the run-off from snow survey data. However, when there is a complication or an un-

[1] Paper prepared for International Commission of Snow and Glaciers, Washington, D. C., September 1939, and printed in SOIL CONSERVATION by special permission.

[2] Consulting engineer, Soil Conservation Service, Berkeley, Calif.

Snow surveyor weighing snow tube and snow core.

usual year, then other factors must be taken into account. It is these unusual years when accuracy of forecasts is most essential.

Where several snow courses on one watershed are measured, the average of all may be used. In other cases, the watershed may need to be elevation-zoned and courses in each elevation zone averaged and the separate zones weighted according to the percentage each bears to the whole. Similarly, it is sometimes found that better results are obtained by weighting individual courses. Each watershed usually proves a law unto itself in this respect and preparing the correlation curve at times becomes an empirical process of trial and error.

Correlation curves are influenced by the combination of at least 10 variables. These variables fall into two groups, the first, watershed variables, and the second, climatic variables. Physical characteristics of any individual watershed are practically constant, but the climatic factors that induce divergence vary from year to year. The two groups of variables cannot be exactly separated in practice because the former is a long-time product of the latter and direct effects of the latter group may be masked by variations in the former. However, for purpose of this discussion, we may arbitrarily differentiate the two groups of variables as follows:

1. Assuming climatic factors as normal each year, the form of the correlation curve for any individual watershed would be influenced by the following factors:

A. Geographical location of watershed.
B. Watershed elevation.
C. Watershed topography.
D. Vegetative cover.
E. Depth and character of soil and underlying formations.

2. Assuming the above watershed factors as unchanging from year to year, the climatic variables which would influence the annual adjustments of the basic correlation curve are:

A. Elevation limits of the snow mantle.
B. Precipitation during the winter season.
C. Precipitation during the run-off season.
D. Watershed subsurface water content at beginning of the run-off season.
E. Climatic trend.

In the first group (watershed factors) the geographic location of the watershed governs the general nature of the relationship between accumulated snow cover and stream run-off, because of the wide divergence in the proportion of the stream flow coming from melted snow in different areas.

Watershed elevation is important in determining percentage of total annual precipitation that will accumulate as snow, higher elevations generally converting a greater percentage of total precipitation to snow. Consequently, total precipitation is more readily determined by the snow-survey method on high watersheds. Usually too, the snow at the highest elevation is the last to melt; therefore, high-elevation watersheds can be counted on to deliver late summer water to streams, whereas low-elevation watersheds deliver a far greater percentage of their snow cover to early summer stream flow.

Watershed topography is important because water from melting snow is more rapidly and more completely delivered to streams from watersheds of steep topography. The more rapid and complete the delivery of water, the higher the correlation between the snow measurement and total resultant stream flow. However, where rapid and complete delivery of water is made, it is often at the expense of sustained low stream flow during late summer months. Therefore, precipitous watersheds generally are poor equalizers.

The snow cover run-off correlation is directly affected by watershed vegetative cover. This effect is threefold: first, as it affects the amount of snow reaching the ground; second, as it influences the rate at which the snow cover melts; and third, as it affects the quantity of water absorbed by the soil. Brush cover, common to western high plateaus, is effective in accumulating snow, but does not effectively retain it. Dense forest cover is effective in retaining snow on the ground, but intercepts relatively large amounts of snow on the tree crowns, and an important part of the intercepted snow may be evaporated back into the air. Connaughton [3] concluded from his and similar studies that even though maximum watershed yield is obtained from denuded areas, open forest cover, without unduly reducing by interception the amount of snow reaching the ground, so retards rate of snow melting that watershed yield is beneficially stabilized. He defined the ideal forest cover as one "honeycombed by 'glades,' whose extent is so related to height of trees that little direct sunlight reaches the snow."

[3] Accumulation and Rate of Melting of Snow, By C. A. Connaughton. Journal of Forestry, Vol. 33, No. 6. 1935.

Mountain water storage occurs in two forms. The first and most obvious perhaps is the enormous storage in snow. Appreciable though less important storage is found below the ground surface, either in the soil mantle or within caverns or interstices of the underlying formations.

Watersheds differ widely in this respect. Portions of the granitic Sierra Nevada range are covered with such a shallow soil mantle and the parent material beneath is so lacking in voids, that relatively little watershed storage other than in the form of snow takes place. Contrasted to this are the lava formations of the Cascades in Oregon and Washington where an immense amount of water is annually stored below the ground surface. Subterranean storage is so great in certain parts of the Cascades that many fair-sized streams originating from subterranean galleries have a near-maximum flow when they first appear on the surface. Springs from which these streams first appear sometimes show an increased rate of flow beginning in October. This might indicate that water from melting snow, either of the current or preceding year, is only then finding surface outlet. On those watersheds preparation of the forecast curve must not only give weight to the current years' snow-water supply, but the previous 2 years' snow supply as well. One correlation weighting used in the Cascades ascribes a weight of 100 to the current year's snowfall, 50 to that of the year before, and 20 to that of the year before that.

Water stored in watershed soil does not by itself contribute to the flow of streams, because water so held is only removed from the soil by evaporation or by plant roots. However, after a watershed soil is filled with water to its field capacity, additional water from the melting snow must either percolate through, to reappear later in the flow of streams, or flow over the ground surface to the closest concentrating channel. Therefore, the capacity of watershed soils for holding moisture is most important in determining what percentage of the snow cover will be required to "prime" those soils, and what residual percentage, if not evaporated, will be then free for direct delivery to streams. A deep dry soil will absorb a large percentage and a shallow wet soil practically none. Between these extremes, any number of soil conditions may exist. Determination of these subsurface water conditions is part of the snow survey program, and already in Utah and Oregon watershed soil-moisture determinations have been included in the snow measuring work.

In the second group (climatic factors), annual variation in the accumulated winter snow-water content is not included, for, all other climatic factors being equal, the annual water-content variations themselves in conjunction with the watershed variables, define the correlation curve.

Deviations from normal of any one of the five climatic variables listed may make necessary an adjustment of the correlation curve. These five variables may be further separated into those which may be considered and allowed for in making up forecasts and those which are not effective until some time after forecasts are issued. These latter are really the most disturbing for they cannot be foreseen or guarded against, yet at times they greatly distress the forecaster by their destructive effect on forecast accuracy.

Heavier than normal snowfall at lower elevations, with consequent lowering of snow lines, does not necessarily mean that snowfall at higher elevations will also be greater. Snow course measurements will of course show whether or not this be the case. Similarly, in the reverse, high-elevation snow may be disproportionately great in some years. In either case the elevation zone weighting method previously referred to in this paper will absorb the abnormality.

The unpredictable climatic factors which by their variance from normal may play havoc with forecasts are precipitation, and temperature and wind movement (factors influencing snow evaporation and rate of melt) during the run-off season. Both factors exert a profound influence on run-off from snow fields. If no precipitation occurs during the run-off season, stream flow may be reduced as much as 50 percent from that which otherwise might be expected. Run-off may be similarly increased by over-much rainfall during this period.

Dry, warm, downslope winds, commonly called "chinook," may take heavy toll of snow in the Rockies and mountains of the Pacific Northwest. This wind in Switzerland is called the "snow eater." A prolonged "chinook" may radically change the snow run-off correlation in a relatively short time by evaporating the snow without increasing run-off. High temperatures, on the other hand, may likewise accelerate evaporation, but at the same time they increase the rate of melting of snow, thus hastening the rate of delivery of snow water to streams and creating early run-off. This is sometimes advantageous where run-off waters are impounded behind dams for future use or irrigation by flood water only, as a greater snow-field yield is secured by rapid run-off. Where means of conserving flush stream flow for later use are lacking, abnormally high temperatures are not desirable because late season water supplies are dissipated before their time of need.

The effect of climatic trend is most closely associated with climatic factor D, inducing either a progressive drying or moistening of the watershed soil, depending on the trend. The trend likewise may be toward decreased or increased precipitation during the run-off season. The effect of trends appears to become less pronounced after the first year or so, when the most marked deviation of the correlation curve will be noted.

Another climatic factor which may be responsible for annual shifting of the correlation curve is variable watershed soil-moisture content and ground-water storage at the beginning of the run-off season. This factor is interrelated to watershed factor E previously discussed. If watershed soils are dry and the water table is low, the effect is to shift the basic correlation curve to the left. Unfortunately, we are not far enough along with the procuring of special data for determining the state of soil moisture and ground water to show whether or not they will serve our purpose.

A full description of how the April precipitation is used to correct forecasts based on snow surveys made a month earlier on Upper San Joaquin River appears in the Transactions of the American Geophysical Union Nineteenth Annual Report.[4] In this as in most cases a wide departure from the normal spring precipitation must occur to make it necessary to correct the April 1 snow-survey water forecast, but there should be preparedness when occasion arises to do so. Fortunately, this does not occur very often, since it is usually urgent that the April 1 forecast be reasonably accurate.

As a rule, our forecast error is less than 10 percent when based solely upon the depth of water found in the ultimate mountain snow pack. However, occasionally we find that the error is exceeded or that 10 percent is excessive. In such cases it is necessary to give attention to some of the other factors, such as the depth, character and water content of the soil mantle, depth to ground water, etc. In these and other respects each watershed presents a different problem. At present we are amidst research aimed to determine, in each case, the watershed factor that will give without fail the desirable final touch of refinement to our forecasts. This correction factor is being sought in the state of soil moisture that exists on the watersheds each

(*Continued on p. 163*)

[4] Development of Snow Surveying in California. By Fred H. Paget.

QUANTITATIVE BASIS FOR EVALUATING EFFECTIVENESS AND APPLICATION OF SOIL CONSERVATION PRACTICES

By R. E. UHLAND [1]

TECHNIQUES for accurately evaluating the effectiveness of soil conservation practices have long been needed. Variation in the fertility of soils, within and between soil types, in degree and length of slope, and other factors must be taken into account in planning for effective erosion control. If a planned soil conservation program for a field or farm is to be accurately evaluated as to effectiveness and practical application, such a measure in its final summation must be in terms of crop yields with consideration given to whether the land is being used wisely, and if the permanency of the soil can be assured. Once a reliable measure of the erosion effects on crop yields can be attained it becomes a simple matter to reflect the values of soil conservation practices and the necessary accompanying farm reorganization in terms of immediate and possible future crop yields. When the effects of different degrees of erosion as represented by various depths of surface soil are portrayed by different crop yields, then it is necessary only to evaluate a practice in terms of time to erode an inch of surface soil in order to be able to predict the degree of permanency of the soil and the rate of modification of crop yields.

Fortunately experimental data are available concerning the rates at which soil is lost by water erosion. These data have been secured on 11 Federal and State cooperative soil erosion experiment stations over a period of time varying from 21 years on the Missouri State Experiment Station at Columbia, to approximately 10 years for most of the cooperative stations.

An analysis of these data shows that the conditions represented vary widely with respect to soil types and fertility, length and degree of slopes, vegetative covers, and cultural treatments. According to these data the vegetative cover, which was markedly influenced by soil type and fertility, exercised the greatest effect on soil and water losses. The degree and length of slope as well as cultural treatments, as would be expected, influenced greatly the rate at which soil erosion occurred.

A complete analysis of these data has been made and the results are set forth in table 1. It will be noted that the crops are grouped into 4 major classes: (1) intertilled crops, (2) small grains, (3) legumes and grasses, and (4) meadow or pasture. These groups are, in turn, subdivided in accordance with the sequence of the different crops. The figures listed represent erosion factors. They are the percentages of the top 7 inches (1,000 tons) of soil that are lost annually through erosion by water for various crops in cropping systems grown on soils representing different degrees and lengths of slopes. The factors marked with asterisks on the table were obtained experimentally on the experiment stations cited above. The remaining values were carefully calculated by extending the above values and by supplementing them by extensive observations made in carrying out evaluation surveys and field tests. These calculated values may be adjusted and refined as rapidly as experimental findings and experience indicate the need and justification.

The values listed in table 1 are for soils that have been under cultivation for a considerable period of time. These soils had lost from 25 to 50 percent of their surface soil and about one-third of their original nitrogen and organic matter. For soils that have lost less than 25 percent of their surface, the factors for the A slopes should be one-half the amount listed. Those for the B slopes should be the amounts listed for the A slopes. Those for the C slopes should be those given for the B slopes, and for the D slopes, the C values should be used throughout the table.

For those soils that have lost more than 50 percent of their surface soil, all values listed should be increased by 25 percent, since the erosion losses are known to become increasingly severe as erosion progresses. For soils showing little need for lime and little response to fertilizer or manure, credit should be given for the use of those soil amendments in determining the efficiency of soil-conservation practices on that farm or field.

By means of the values presented in table 1, it becomes a simple procedure to determine or to evaluate the effectiveness of soil-conservation practices planned for any individual field or farming area. To facilitate this evaluation there are listed in table 2 six efficiency rankings based on the rate at which the loss of the surface 7 inches of soil may be reduced and the life of the soil extended. In this consideration, the efficiency rating for soil conservation was arbitrarily

[1] Liaison officer, divisions of research and operations, Soil Conservation Service, Washington, D. C.

TABLE I EROSION FACTORS EXPRESSED IN PERCENTAGE OF TOP SEVEN INCHES (1000 TONS) OF SOIL LOST ANNUALLY THROUGH EROSION BY WATER FOR DIFFERENT CROPS OR CROPPING SYSTEMS ON DIFFERENT DEGREES AND LENGTHS OF SLOPE

Supporting Treatment		1				2				3				4				5				6				7				8			
System of Cropping or Land Use (a)	Average Length of Slope (a)	Crop or Rotation without supplemental practices				Crop or Rotation + lime & fertiliser (including manure inoculation as needed)				Crop or Rotation Plus Contour Cultivation				Crop or Rotation + lime & fertiliser + contour cultivation				Crop or Rotation + Strip Cropping + Contour Cultivation				Crop or Rotation + Strip Cropping + contour cultivation + lime & fertiliser				Crop or Rotation + terracing + contour cultivation				Crop or Rotation + terracing + contour cultivation + lime & fertiliser			
		Slope Class				Slope Class				Slope Class				Slope Class				Slope Class				Slope Class				Slope Class				Slope Class			
		A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Planted annually to intertilled crops (5 or more years)	Short	*2.0	*4.0	*8.0	*12.0	1.5	*3.0	*6.0	*9.0	1.5	*3.0	*6.0	9.0	1.0	*2.0	*4.0	6.0	1.0	*1.5	*2.0	3.0	*1.0	*1.0	*1.5	2.0	*1.0	*1.2	*1.5	3.0	*0.8	*1.0	*1.2	2.5
	Medium	4.0	8.0	12.0	16.0	3.0	6.0	9.0	12.0	3.0	6.0	9.0	12.0	2.0	4.0	6.0	8.0	1.5	2.0	2.5	3.5	1.5	1.5	2.0	2.5	1.0	1.2	1.5	3.0	0.8	1.0	1.2	2.5
	Long	6.0	12.0	16.0	20.0	4.5	9.0	12.0	16.0	4.5	9.0	12.0	16.0	3.0	6.0	8.0	10.0	2.0	2.5	3.0	6.0	2.0	2.0	2.5	5.0	1.0	1.2	1.5	3.0	0.8	1.0	1.2	2.5
	Extra long	8.0	16.0	20.0	24.0	6.0	12.0	16.0	20.0	8.0	14.0	18.0	22.0	6.0	12.0	16.0	20.0	4.0	8.0	10.0	16.0	3.5	4.0	6.0	12.0	1.0	1.2	1.5	3.0	0.8	1.0	1.2	2.5
Intertilled crops alternated with small grains (maximum of 2 years)	Short	*1.5	*3.2	*6.5	10.0	1.3	*2.0	*5.0	7.0	1.3	*2.2	*5.0	7.0	1.0	*1.5	*2.0	4.0	*1.0	*1.3	*1.5	2.0	0.8	*0.8	*1.0	1.5	0.8	*1.0	*1.2	2.5	0.6	*0.8	*1.0	2.2
	Medium	3.2	7.0	10.0	13.0	2.5	5.0	7.0	9.0	2.5	5.0	7.0	9.0	1.5	3.0	4.0	6.0	1.0	1.5	2.0	2.5	1.0	1.0	1.5	2.0	0.8	1.0	1.2	2.5	0.6	0.8	1.0	2.2
	Long	5.0	10.0	13.0	16.0	3.5	7.0	9.0	12.0	3.5	7.0	9.0	12.0	2.0	4.0	6.0	8.0	1.5	2.0	2.5	3.0	1.3	1.3	2.0	2.5	0.8	1.0	1.2	2.5	0.6	0.3	1.0	2.2
	Extra long	7.0	13.0	16.0	20.0	4.5	9.0	12.0	15.0	6.0	11.0	14.0	18.0	3.0	6.0	10.0	16.0	2.0	4.0	6.0	8.0	1.5	2.0	3.0	4.0	1.0	1.2	1.5	2.5	0.6	0.8	1.0	2.2
Intertilled crops in rotation with small grains, legumes & grasses (b) (maximum of 2 years)	Short	*1.0	*2.0	*4.0	*6.0	1.0	*1.5	*3.0	*4.5	1.0	*1.5	*3.0	4.5	1.0	*1.2	*1.5	*2.0	0.8	*0.8	*1.0	1.5	*0.3	*0.4	*0.5	0.6	*0.4	*0.5	*0.6	1.0	*0.3	*0.4	*0.5	0.6
	Medium	2.0	4.0	6.0	8.0	1.5	3.0	4.5	6.0	1.5	3.0	4.5	6.0	1.2	2.0	3.0	4.0	1.0	1.0	1.5	2.0	0.3	0.4	0.5	0.6	0.4	0.5	0.6	1.0	0.3	0.4	0.5	0.6
	Long	3.0	6.0	8.0	10.0	2.3	4.5	6.0	8.0	2.3	4.5	6.0	8.0	1.5	3.0	4.0	6.0	1.3	1.3	2.0	2.5	0.3	0.4	0.5	0.6	0.4	0.5	0.6	1.0	0.3	0.4	0.5	0.6
	Extra long	4.0	8.0	10.0	12.0	3.0	6.0	8.0	10.0	3.0	6.0	8.0	10.0	2.0	4.0	6.0	10.0	1.5	1.3	1.5	2.0	0.4	0.5	0.6	1.0	0.3	0.4	0.5	0.6	0.3	0.4	0.5	0.6
Intertilled crops in rotation with small grains, legumes, grasses (maximum of 1 year)	Short	*0.9	*1.5	*2.5	4.0	*0.8	*1.0	*2.0	3.0	0.8	*1.0	*2.0	3.0	0.6	*0.8	*1.0	1.2	0.5	*0.6	*0.8	1.0	0.3	*0.4	*0.4	0.5	*0.3	*0.4	*0.5	0.8	*0.3	*0.4	*0.4	*0.5
	Medium	1.8	2.5	4.0	6.0	1.5	2.0	3.0	5.0	1.5	2.0	3.0	5.0	1.0	1.2	1.5	2.0	0.6	0.8	1.0	1.5	0.3	0.4	0.4	0.5	0.3	0.4	0.5	0.8	0.3	0.4	0.4	0.5
	Long	2.5	4.0	6.0	8.0	2.0	3.0	5.0	7.0	2.0	3.0	5.0	7.0	1.2	1.5	2.0	4.0	0.8	1.0	1.5	2.0	0.3	0.4	0.5	0.8	0.3	0.4	0.5	0.8	0.3	0.4	0.4	0.5
	Extra long	3.0	6.0	8.0	10.0	2.5	5.0	7.0	9.0	2.5	5.0	7.0	9.0	1.5	2.0	4.0	6.0	1.0	1.5	3.0	5.0	0.5	0.8	1.0	3.0	0.3	0.4	0.5	0.8	0.3	0.4	0.4	0.5
Small grain grown continuous or alternated with intertilled crops	Short	1.5	*2.0	*2.5	*3.0	1.3	*1.5	*1.8	2.3	1.3	*1.5	*1.8	2.3	1.0	*1.2	*1.5	1.8	1.0	*1.2	*1.5	1.8	*0.4	*0.5	*0.6	1.0	*0.4	*0.5	*0.6	0.5	0.3	*0.3	*0.4	0.5
	Medium	2.5	3.0	3.5	4.0	2.2	2.5	2.8	3.3	2.2	2.5	2.8	3.3	1.2	2.0	2.5	3.0	1.2	2.0	2.5	3.0	0.4	0.5	0.6	1.0	0.4	0.4	0.4	0.5	0.3	0.3	0.3	0.4
	Long	3.0	4.0	4.5	5.0	2.8	3.0	3.2	4.2	2.8	3.0	3.2	4.2	1.5	2.5	2.5	3.5	1.5	3.0	3.5	4.2	0.4	0.5	0.6	1.0	0.4	0.4	0.4	0.5	0.3	0.3	0.3	0.4
	Extra long	4.0	5.0	6.0	7.0	3.0	4.0	4.2	5.2	3.0	4.0	4.2	5.2	2.0	3.5	3.5	4.2	2.0	4.0	4.5	5.0	0.4	0.5	0.6	1.0	0.4	0.4	0.4	0.5	0.3	0.3	0.3	0.4
Small grain grown in rotation with intertilled crops, legumes, grasses	Short	0.8	*1.0	*1.2	*1.5	0.6	*0.8	*1.2	*1.5	0.6	0.8	*1.2	1.5	0.5	0.6	*0.7	0.8	0.5	0.6	*0.7	0.8	*0.3	*0.3	*0.3	*0.4	*0.3	*0.3	*0.3	0.4	*0.2	*0.2	*0.2	0.3
	Medium	1.2	1.5	1.8	2.0	0.8	1.2	1.5	2.0	0.8	1.2	1.5	2.0	0.6	1.0	1.2	1.5	0.6	1.0	1.2	1.5	0.3	0.3	0.3	0.4	0.3	0.3	0.3	0.4	0.2	0.2	0.2	0.3
	Long	1.5	2.0	2.2	2.5	1.2	1.5	2.0	2.5	1.2	1.5	2.0	2.5	0.7	1.2	1.5	1.8	0.7	1.2	1.5	1.8	0.3	0.3	0.3	0.4	0.3	0.3	0.3	0.4	0.2	0.2	0.2	0.3
	Extra long	2.0	2.5	3.0	33.5	1.5	2.0	2.5	3.0	1.5	2.0	2.5	3.0	0.8	1.5	1.8	2.0	0.8	1.5	1.8	2.0	0.3	0.3	0.3	0.4	0.3	0.3	0.3	0.4	0.2	0.2	0.2	0.3
Small grain and meadow (including clover) rotation	Short	0.4	*0.5	*0.6	0.7	*0.2	*0.3	*0.4	0.5	0.2	0.3	0.4	0.5	0.1	*0.2	*0.3	0.4	0.1	*0.2	*0.3	0.4	*0.1	*0.1	*0.1	0.1	*0.1	*0.2	*0.2	*0.2	*0.1	0.1	*0.1	0.1
	Medium	0.6	0.8	0.9	1.0	0.3	0.4	0.5	0.6	0.3	0.4	0.5	0.6	0.2	0.3	0.4	0.5	0.2	0.3	0.4	0.5	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
	Long	0.8	1.0	1.2	1.3	0.4	0.5	0.6	0.7	0.4	0.5	0.6	0.7	0.3	0.4	0.5	0.6	0.3	0.4	0.5	0.6	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
	Extra long	1.0	1.2	1.5	1.7	0.5	0.6	0.7	0.8	0.5	0.6	0.7	0.8	0.4	0.5	0.6	0.7	0.4	0.5	0.6	0.7	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.3
Legumes and grasses grown in rotation	Short	0.2	*0.2	*0.3	*0.4	*0.1	*0.1	*0.1	*0.2	0.1	0.1	*0.1	0.2	0.1	*0.1	*0.1	0.1	0.1	0.1	*0.1	0.1	*0.0	*0.0	*0.0	*0.0	*0.1	*0.1	*0.1	*0.1	*0.0	*0.0	*0.0	*0.0
	Medium	0.2	0.3	0.4	0.5	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
	Long	0.2	0.4	0.5	0.6	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
	Extra long	0.2	0.5	0.6	0.7	0.1	0.1	0.2	0.4	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Meadow or pasture remaining 5 or more years	Short	0.1	*0.1	*0.2	0.2	0.0	*0.0	*0.0	*0.0	0.1	0.1	*0.1	0.1	0.0	*0.0	*0.0	0.0	0.1	0.1	*0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
	Medium	0.1	0.1	0.2	0.2	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
	Long	0.1	0.1	0.2	0.2	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
	Extra long	0.1	0.1	0.2	0.2	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0

* Values were obtained experimentally. Other values were calculated by extending experimentally-determined values

(a) Intertilled crops include corn, cotton, tobacco, sorghum, soybeans, etc.
Small grains include wheat, oats, barley, rye, etc.
Legumes and grasses include red clover, alsike clover, sweet clover, lespedeza, alfalfa, timothy, redtop, and various mixtures.
Meadows and pastures include the same crops listed under legumes and grasses, but remaining three or more years.

(b) If two years of intertilled crops are grown and a good cover crop is grown after the first intertilled crop, the annual soil loss for each of the two years will be the same as where but one intertilled crop is included in the rotation.

(c) Short — less than 400 feet.
Medium — 400 to 800 feet.
Long — 800 to 1200 feet.
Extra long — over 1200 feet.

placed at zero where soil is lost at a rate as high as 1 inch (143 tons per acre) per year.

TABLE 2.—*Efficiency rank and classes based on estimated time to erode suface 7 inches of soil*

Rank		Calculated life of surface 7 inches of soil (years)
Class	Percent	
Excellent	95 to 100	500 to 1,000.
Very good	85 to 94	150 to 499.
Good	75 to 84	75 to 149.
Fair	65 to 74	50 to 74.
Poor	55 to 64	25 to 49.
Very poor	Less than 55	Less than 25.

The application of such a procedure is illustrated in table 3 which shows the relative soil losses from different systems of cropping along with the relative efficiency rating expressed in percentage and rank.

The fields on which these practices are applied represent different slope classes with respect to degree and length. It is apparent that the supplemental or supporting treatments needed to control erosion adequately on a given field are dependent upon many factors. Some of the most important of these factors are type of rotation or cropping system used, the length and percent of slope, need for lime and fertilizer, along with the erosion which has previously taken place. The degree of slope classification used is the same as that used in soil conservation surveys. The actual length of the slope classes may be adjusted for the different problem areas and can be used to take care of differences in erodibility of various soil types or groups that are well recognized. In like manner, these erosion factors will apply equally well to classes of land according to use capability as discussed in the Soil Conservation Survey Handbook (U. S. Department of Agriculture Miscellaneous Publication No. 352).

These erosion factors, listed under the different supporting treatments, are based on the assumption that

TABLE III EFFICIENCY OF SOIL CONSERVATION PRACTICES

(Based upon relative soil losses from various systems of cropping on slopes of variable lengths and degrees, supplemented by different supporting treatments)

System of Cropping or Land Use	Slope Degree Class	Slope Length Class	Supporting Treatments (1)	Ann. Soil Loss Tons per Acre	Estimated Time to erode surface 7 inches Years	Efficiency Rank	Efficiency in preventing erosion Percent
Cropped annually to intertilled crops	C	Long	1	160	6/	Very Poor	0
" " " " "	C	Long	4	80	12.5	Very Poor	18.3
Cropped annually to small grain	C	Long	1	45	22.2	Very Poor	47.9
" " " " "	C	Long	4	28	35.7	Poor	59.5
2 yrs. intertilled, 1 yr. small grain, 1 yr. meadow	C	Long	1	42	23.8	Very Poor	52.8
" " " " " " "	C	Long	4	19	52.6	Fair	66.1
" " " " " " "	C	Long	6	3¼	307.7	Very Good	89.6
" " " " " " "	C	Long	8	3	333.3	Very Good	90.3
1 yr. intertilled, 1 yr. small grain, 2 yrs. meadow	C	Long	1	23	43.5	Poor	62.8
" " " " " " "	C	Long	4	9	111.1	Good	79.9
" " " " " " "	C	Long	6	2	500.0	Excellent	95.0
" " " " " " "	C	Long	8	1.5	666.6	Excellent	96.7
1 yr. intertilled, 1 yr. small grain, 2 yrs. meadow	C	Extra long	1	30	33.3	Poor	58.5
" " " " " " "	C	"	4	15	66.6	Fair	72.0
" " " " " " "	C	"	6	5	200.0	Very Good	86.5
" " " " " " "	C	"	8	1.5	666.6	Excellent	96.7
1 yr. intertilled, 1 yr. small grain, 2 yrs. meadow	C	Medium	1	16.5	60.6	Fair	69.5
" " " " " " "	C	Medium	4	7/	142.9	Good	84.2
" " " " " " "	C	Medium	6	2-	500.0	Excellent	95.0
" " " " " " "	C	Medium	8	1.5	666.6	Excellent	96.7
1 yr. intertilled, 1 yr. small grain, 2 yrs. meadow	B	Short	1	7/	142.9	Good	84.2
" " " " " " "	B	Short	4	4	250.0	Very Good	87.9
" " " " " " "	B	Short	6	2-	500.0	Excellent	95.0
" " " " " " "	B	Short	8	1.5	666.6	Excellent	96.7
Continuous meadow	C	Long	1	2	500	Excellent	95.0
" "	C	Long	2	0	1000/	Excellent	100.0

(1) Number refers to supporting practice or practices listed under corresponding number in Table I.

the supporting practices are initiated and carried out in conformity with specifications founded on the best information now available. It is obvious, of course, that improper terracing of land by the use of excessive vertical intervals, either excessive or inadequate grades, or improperly protected outlets, will not furnish the protection indicated in tables 1 and 3. Likewise, in the practice of strip cropping, all precautions must be taken to ensure minimum deviation from the contour, proper sequence and arrangement of crops on the strips, and the protection of all natural depressions with grassed waterways, if the protection indicated by the erosion factors is to be attained.

It is apparent from the data in table 3 that several supporting practices may provide the same degree of efficiency with respect to erosion control. This, therefore, makes it very necessary that the different possible conservation programs be considered from the standpoint of their relative effectiveness and economic application, so that the most appropriate control measures may be selected for given conditions.

Even though soil types differ markedly, yet they may be grouped and classified on the basis of their erodibility, their suitability for cultivation, and the supporting treatments or practices needed to protect them against erosion and fertility depletion. In the grouping of these soils and the prescription of suitable cropping systems and supporting conservation practices, due consideration must be given to the different slope classes with respect to degree and length as well as to the erosion which has already occurred. In the mapping procedure for soil conservation surveys, the slope classes A, B, C, and D represent significantly various ranges in degrees for different regions and States, as well as for soil types within regions. In like manner, the lengths in feet prescribed for the short, medium, long, and extra long slopes may vary widely from State to State and perhaps, in many instances, for different soil types and soil groups within the State.

The losses of plant food from cultivated land, through water erosion in the humid region, have been shown to be many times larger than are the losses incurred through the growing and removing of crops. Proper handling of the crop residues and manure contributes decidedly to the maintenance of the organic matter and nitrogen content of the soil. The very marked effect of straw or crop residues left as a mulch on the surface of the soil has been demonstrated and measured. This mulch increases the amount of water that filters into the soil; it lessens the losses of moisture through evaporation, and it reduces the amount of soil and plant food lost by erosion. With proper use of the crop residues while the cropping system is being carried out, the infiltration rate and amount will increase while erosion losses decrease.

On a few selected projects in Regions 3 and 5 a plan has been initiated for checking the calculated erosion factors listed in table 1. A number of farms on each project will be studied to ascertain the complete cropping history of each field on the farm dating from the time the field was first broken out of sod. This of course will limit the number of farms and fields to be studied, since it will be possible to secure adequate information on but a limited number of farms and fields on each project. For those farms and fields on which a complete cropping history can be secured, a very careful survey will be made whereby the depth of surface soil associated with slopes of varying classes of degree and length will be determined. In the beginning, observations will be confined to locations in each of the fields where the percent of slope is near constant.

Readings of soil depth will be initiated at the top of the ridge in the field and will be made at each 100-foot interval. Each field may furnish as many as 20 or more uniform slopes representing varying degrees, lengths, and different exposures, thus providing extensive data on each field. A record will also be secured of the predominant direction of cultivation and whether lime, manure, or commercial fertilizer has been used. After determining the amount of soil that has been lost by erosion for varying but known conditions, the average annual losses can be calculated.

In order to carry out this plan, it is obvious that we must be able to determine accurately the depth of the surface soil. This is somewhat complicated by the fact that, as soon as the depth of the original surface soil becomes less than the depth of soil turned by the plow, there is a mixing of the surface soil with the subsoil. For example, let us assume that a surface soil is 12 inches deep and plowed at a uniform depth of 6 inches, and that the management is such that there is an average soil loss by erosion of 1 inch in 5 years. This would mean that, at the end of 30 years, 50 percent of the surface soil would be gone. At the end of the thirty-first year the surface 6 inches of soil would consist of but 5.8 inches of the original surface and 0.2 inch of subsoil. After 60 years, 12 inches of soil would have eroded away, but there would yet remain 2.24 inches of surface soil since that removed through erosion consisted of 9.76 inches of the original surface and 2.24 inches of subsoil. After 100 years, although 20 inches of soil would have been lost, there would yet

remain approximately 0.6 inch of the original surface. Even after 150 years when 30 inches of soil would have been eroded away, consisting of 11.9 inches of the original surface and 18.1 inches of subsoil, 0.1 inch of the original surface soil would yet remain. It is recognized in making these calculations that the erosion process does not operate uniformly over a field to remove the surface inch without touching the layers beneath. An entire examination of the area in question will give the variation.

For the purpose of determining the accuracy with which the depth of the surface soil can be measured where considerable mixing with the subsoil has taken place, soil samples will be taken on two of the projects and examined with regard to the organic matter and exchangeable bases in the 7-inch layer. Preliminary trials were initiated this fall on the projects at Bethany, Mo., and Shenandoah, Iowa, to develop the technique and to test the possibilities of this approach toward determining the amount of surface soil that remains. The organic matter and the exchangeable bases will be compared with the quantities found in the surface, subsurface, and the subsoil where greater depth has prevented any mixing of the subsoil with the surface. A careful examination of the soil profile within each field will also be of great assistance in the original mapping of the depth of the surface soil.

Measurements of crop yields, as affected by soil depths, are being made on a few projects in Regions 3 and 5. The first crop to be used extensively is corn, since this crop is known to be a good indicator of fertility and is a major crop in these two regions. This crop also lends itself well to field sampling for yield determinations and this is an important factor. A few yield determinations already have been made in Iowa and Ohio. It was indicated by the personnel at Greenfield, Iowa, for example, that for 1938 a decrease of 2 inches in the soil depth resulted in a decrease of approximately 10 bushels per acre in the corn yield. From this it is not difficult to appreciate the importance of reducing or eliminating erosion while satisfactory yields are being secured so that these yields may be sustained. Past experiences in observations have indicated a wide variation in the effects of erosion on crop production. With the adoption of appropriate soil conservation practices, including soil amendments, some severely eroded lands representing certain soil types can be made to produce fairly high yields. However, for most soils this is not the case.

After it is established what the erosion factors are that give the rate of soil loss from land having varying slopes with respect to degree and length, and having different crops and supporting treatments or practices, it will be simple to predict the rate of soil removal and the corresponding decline in productivity. Because these erosion factors are based on what actually has happened to our soils in the past under varying conditions, and since we can expect little change in climate, we may expect erosion to occur under similar conditions in the future much as it has in the past.

By determining the effects of different soil depths with and without fertilizer or other soil amendments on crop yields, and by using the erosion factors for calculating the rate of soil loss, we have a very definite basis for calculating the benefits that may be derived throughout the lifetime of both the present and future generations when different cropping systems supported by various soil conservation practices are followed. These findings will prove very helpful in determining the cost and benefits to be expected from following different soil conservation practices and will assist in the planning for a farm, a project, or a district. These data will prove equally useful in evaluating the results to be expected on different farms and projects where soil conservation practices already have been planned or initiated.

WOODLAND CARIBOU IN MINNESOTA

(*Continued from p. 143*)

"The animals in captivity are fed mosses (of which many truckloads were stored for winter use), lichens, oatmeal, milk, and succulent plants. The seven animals consume almost a case of canned milk a day, and refuse to eat hay or other plant materials foreign to their natural habitat. They are given minerals regularly, and this undoubtedly accounts in part for their rapid growth. Their senses of taste and smell are extremely keen; it is, for instance, impossible to get the animals to take any brand of milk other than that first fed to which they have become accustomed. Even the addition of one tablespoonful of a different brand to a cup of milk is sufficient to cause refusal.

"The animals will be transferred to the larger pasture in the fall of 1939 for the breeding season. From this pasture they will be liberated, at almost 2 years of age, and it is hoped that they will join the other Minnesota caribou."

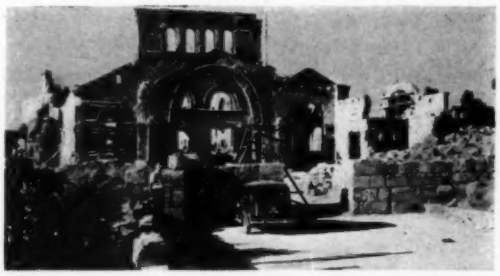
So much for Manweiler's interesting story. I am sure the reader will agree with me that the restocking experiment gives every indication of success.

However, the job is not finished. As has been shown in the case of most successful stocking experiments with either big game or game birds, it is advisable to obtain and liberate some more of the animals a year or two after the first attempt at stocking.

Erosion-Control Lessons From Old-World Experience

III. EROSION AT ITS WORST, AND A HUNDRED DEAD CITIES

By WALTER C. LOWDERMILK [1]



Entrance to Kalaat Samaan, the great sanctuary of St. Simon the Stylite. Some restoration is being done by the Department of Antiquities of Syria.

A SOIL conservationist finds in Syria many lessons which we of the United States may well take to heart. There mankind has lived and tilled vanishing lands for thousands of years. Decisive results of wasteful and inconsiderate use of land, as well as of the conservation of soil, may be found in the varied types of country of Syria. One may easily read the land use through the centuries writ large across the landscape, and see the fate of similar areas in the United States, unless a program of full conservation of land and waters is put into effect before it is too late.

Syria holds some of the grandest ruins to be found in the world. The ruins of Baalbek are without compare in grandeur and preservation to any that we have seen; they are some of the most magnificent ruins in the world today. There are huge stone blocks, 30 feet long, 14 feet high, and 14 feet wide, brought from the quarry about a mile away and laid down as foundation stones. Massive monolithic pillars of red granite had been quarried at Aswan, Egypt, and shipped 600 miles down the Nile River, and then across the Mediterranean to the North Syrian coast, unloaded and then rolled by human hands over a 5,000-foot pass across the Lebanon Mountains and down into the Bekaa and to Baalbek.

Hidden at the edge of the mysterious desert of Syria are the almost equally striking ruins of Palmyra, where Queen Zenobia so long defied legions of the Romans. On the North Syrian coast, Byblos, one of the oldest cities in the world, is gradually being brought out of its grave after being buried for centuries in debris. Its fascinating past is now being reconstructed through archaeological finds. Byblos was a town long before it was the Egyptian port from which the famous Cedars of Lebanon were shipped to Egypt for construction of dwellings and temples in the Nile Valley.

"Egbert, that young old man," 30,000 years old, has been covered with 40 feet of debris since he lived in a paleolithic cave home. Only last year his skeleton was discovered by Fathers Ewing, S. J., and Doherty, S. J., in the course of excavations of a paleolithic site near Beyrouth.

The long and significant past of this part of the world is beginning to be made known, but thus far, little attention has been given to the fate of the land which has been cleared and cultivated, terraced and wasted through the centuries, to supply the food and textiles which made possible the rise of man out of barbarism.

These great ruins in Syria reveal a past prosperity and opulence of populations under Egyptian, Greek, Roman, and Crusader domination. It would be impossible for these populations to thrive today on the surrounding stony sterile slopes. To a soil conservationist, the most striking ruins are those of about a hundred or more Dead Cities in North Syria, where soil erosion has done its worst and spread a ghastly destruction over a landscape of 1,150,000 acres of former productive lands.

These Dead Cities in their almost perfect state of preservation seem to have been more asleep than dead for 13 centuries. They have not been buried by erosion, but stand high on their rock foundations on the limestone hills, from which 3 to 6 feet of productive *terra rosa* soil have been washed away. This soil was the basis of a remarkable prosperity and opulence in ancient times for this region with its populous centers.

This erosion devastated area is in reality a huge graveyard in which cities of cut-stone stand like tombstones, weathered into a monotonous grayness like that of the exposed skeleton country rock of the rolling hills. Seldom does one find remnants of the red earth which formerly clothed the limestone hills; it is lodged in the narrow valley floors where it was saved

[1] Assistant chief, Soil Conservation Service, Washington, D. C.

from being swept out to the Orontes River by winter storms. The good earth is completely gone from the slopes except where walls of ruined buildings have held back small patches of soil. In these patches a few vines or olive trees stand as sorry remnants of a former profitable land use. Otherwise, the landscape is gray desolation, glaring in the summer heat and bleak in the winter cold. Sometimes one finds a yellow and gold desert varnish, or "patina," on the bared rock, giving a marvelous effect. It is fascinating to see toward evening the fairy spectacle of the ruins of Rouweiha silhouetted strange and mysterious against the evening sky. It appears as a modern city, devastated by war or fire. Many of the villas or churches had roofs and would be habitable today. The cut-stone was of such excellent quality and workmanship that the sculpture, moldings, inscriptions and escutcheons have resisted the weathering of centuries of abandonment.

These ruins are found in a region that is almost a desert today, lying within an area outlined by four great ancient cities, namely, Antioch on the west, Apamu (Kalaat el-Moudik) on the south, Chalcis (Quuniesrin) on the east, and Berea (Aleppo) on the northeast. Traced out on the map this region is a long rectangle about 20 miles wide and 90 miles long, or about 1,800 square miles, a huge area where erosion has done its worst.

The Dead Cities of North Syria reveal a period of history of which very little is thus far known. It was a local civilization but very advanced and rich, with a highly developed and distinctive Syrian art found nowhere else. This art was surprisingly delicate, full of freshness and originality. Father Mattern outlines the steps wherein one may follow a constant rise from the third to the seventh century without sign of decadence. But it was cut off in its vigor of life and development by the invasion of the Persians in 614 and the conquest of the Arabs in A. D. 630. These nomad invaders killed the inhabitants, blotted out their art and culture, and destroyed their cities, their vineyards and their olive orchards, and the traditions of their agriculture. Today, after thirteen centuries of neglect and patch cultivation to cereals by semi-nomadic descendants of the invaders, and of over-grazing by their goats, soil erosion has completed the destruction of the good earth with a thoroughness that has left this once fertile land a complete man-made desert, void of vegetation, water, and soil, except in rare pockets with scanty cover of crops and thorn bushes. The ruins of a highly developed architecture tell of the advanced culture of this region.

The first revelation of these Dead Cities of North Syria, after an undisturbed sleep of more than a thousand years, was made in 1861 by Viscount Melchoir de Vogue, who published his findings of his field studies in two volumes. In 1888 Fathers Jullien and Soulerin made a further study, which was reported in the "Review of Catholic Missions." In 1904 and 1909 two American expeditions were sent out from Princeton and added much information on the history and inscriptions of these Dead Cities, which has been published in three volumes. And in 1928, 1929, and 1931 Father Joseph Mattern, S. J., made a study of the ruins of churches in this area, but his scholarly interest lead his observations into a general account of these remarkable ruins. Few other expeditions have been made, due to the insecurity of traveling about in this desolate country. Another survey, made with Dr. Alford Carlton, President of the Aleppo American College, appears to be the first to study the lost agriculture surrounding the ruins.

The area of Jebel Riah and Kalaat Samaan, where most of the largest cities are found, were visited during one of the hottest periods of summer. From a point about halfway up the Kubbit Babutta, could be counted, lying to the north, at least 15 deserted and Dead Cities. The rolling foothills, once clad in vineyards and olive orchards, are gashed with deep ravines where remain, here and there, small pockets of soil which lodged as the red earth was being washed off the slopes. Today, only a few goats find meager herbage in this formerly productive area. A few scattered, sordid villages house a mere fraction of the numbers of a former progressive population. Usually, as at Kfar-Rouma, these villages are built on the site of former cities and the inhabitants have made use of the ruins as shelters or quarried rock from them to construct crude dwellings. There are places where the building blocks have been thrown pell-mell one upon the other as by an earthquake, but in other places stand buildings which appear to have been burned with fire only yesterday.

Particularly lending themselves to study, are the well preserved cities of Gerade, El Gami, Bara, and the ruins of Kalaat Samaan. In the center of the ruins of Gerade is a closely set group of buildings with stalls, small markets, and dwellings nearby. Around this center are a great number of villas grouped without reference to symmetry. The villas in the outskirts have many out-buildings, and are more spacious and richer than the houses in the interior of the city. The buildings of a villa are grouped around a court entered by a gate, often monumental and sometimes

surmounted by a tower. On the ground floor, the dwelling house usually has a long gallery supplied with elegant columns, on which open the doors and windows of apartments. Houses rarely opened on the streets. Beautiful motifs are sculptured in the rock lintels of doorways and windows. On each side of the doors we usually found two niches of different sizes. It is supposed the smaller one contained an olive oil lamp to light the gallery and the second and larger one sheltered the icon of a saint.

The town of Bara is described by the historians of the Crusaders in the Chronicles. It is evident that a civilization had been cut off in its flowering. Ruins of a great church at Bara indicate a striking elegance, and must represent, with the church of St. Simon at Kalaat Samaan, the culminating point of the development of Syrian architecture. Especially fine is a carved entablature, 30 by 32 inches and 7 feet 4 inches long in the basilica at Bara. The good taste and fineness of its decoration make one conclude that when it was built in 585 nothing predicted the decadence of this art or the oncoming catastrophe.

In this graveyard of cities are the ruins of the largest church built prior to the Twelfth century and may even claim to be the largest church yet built in the Near East. One is astonished at the view of the immense sanctuary of St. Simon. Its length is 325 feet and width 290 feet with a total area of 94,000 square feet. The rooms and galleries, baptistry and façade are almost intact. But the arched roof of the huge octagonal central room, around which these were grouped, had collapsed. Around all the ruined center were arches and columns within an enclosing outer wall with towers which must have given it the appearance of a fortress. This octagonal central room, 90 feet in diameter, appears to be unique in architecture. Each side is pierced by an arch supported by two monolithic columns. But it is of greatest interest because it housed the 65-foot pillar upon which St. Simon lived for 37 years until his death in A. D. 459. The immense height of the roof doubtless contributed to its fall, while other roofs remain intact.

After Simon's death, crowds from the four corners of the Christian world continued to come in great numbers. The resulting flow of money to this sanctuary led to the construction of this magnificent church enclosing his pillar. The great sanctuary, dedicated to St. Simon, is the synthesis of all that Syrian art has produced, and will remain an eloquent evidence of the creative power of Syrian architects as well as the faith of all this part of the Orient.

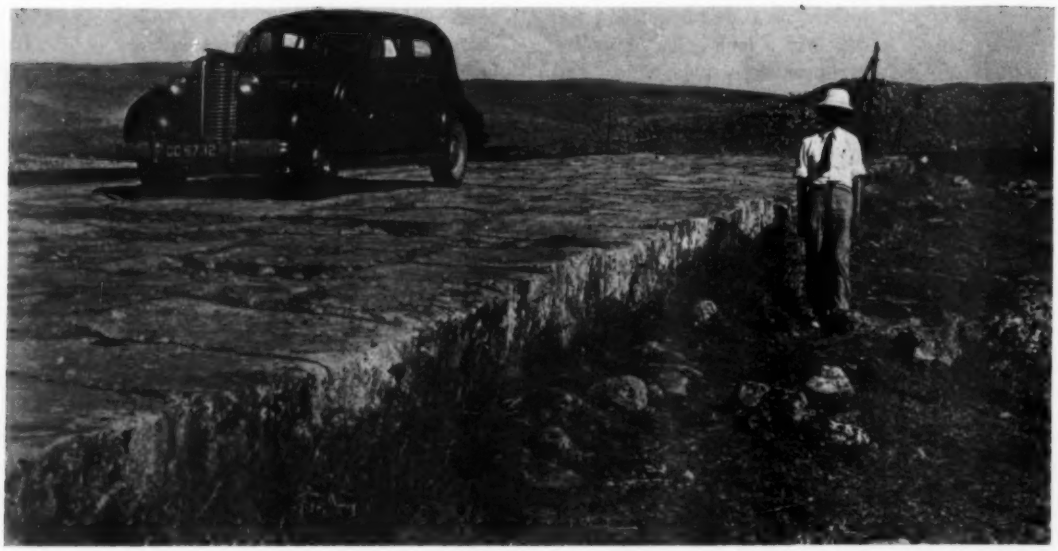
This church was not captured until 350 years after the Arab invasion in A. D. 630, when in A. D. 980 the Emir of Aleppo besieged the sanctuary, which had become a religious fortress. He captured and sacked it; some of the priests he killed, others he sold to slavery.

The extent and beauty of all these ruins show that this desolation of the land has not always existed. The present rocky hills, because of their having no soil, are victims of torrential run-offs each winter rainy season; but in summer there is no water except that accumulated in cisterns. The barren rocky hills are evidently far different from their former condition of beauty and productive fields in the valleys and fruitful olive orchards and vineyards on the slopes, which supported a flourishing civilization.

Contemplation of these ruins raises a number of questions. How can one account for ruins of luxurious cities with buildings constructed of choice material in a manner to endure the ages and in a region which today is denuded, poor, meagerly supporting a few hundred miserable families? How can one explain the former populous centers and prosperity? Whence came such wealth which permitted them to satisfy their artistic tastes and a refined luxury in homes, public buildings, and churches?

This region was once covered with extensive forests. Present day remnants indicate that the principal species were of oak, pine, cypress, and cedar in the higher elevations. Evidence of the forest is found in the architecture. Had not an abundant supply of timber been available the architects would have developed a different type of construction, as they did in the Hauran and elsewhere as we saw in Um Jemal, where timber was not readily accessible. These villas and grand rooms and churches required sturdy timbers of wood as called for by notches in the walls at El Gami, Bara, and other ruins. The ceilings were generally of wood. Much timber was also required for the galleries and furniture and fuel for heating the villas and the water for the baths. Large timbers must have been needed to raise the enormous blocks of stone used in construction, and to build the forms on which were laid the heavy stone arches. Thus for four centuries at least there must have been a sufficient supply of timber in the near vicinity, and of an amount to arouse no anxiety for the future. The removal of the forest doubtless took place as a slow deforestation of the mountains and cultivation of cleared areas, and later the planting of vineyards and olive orchards on a vast scale.

Father Mattern holds that this area was definitely an intensive agricultural country. The location of the



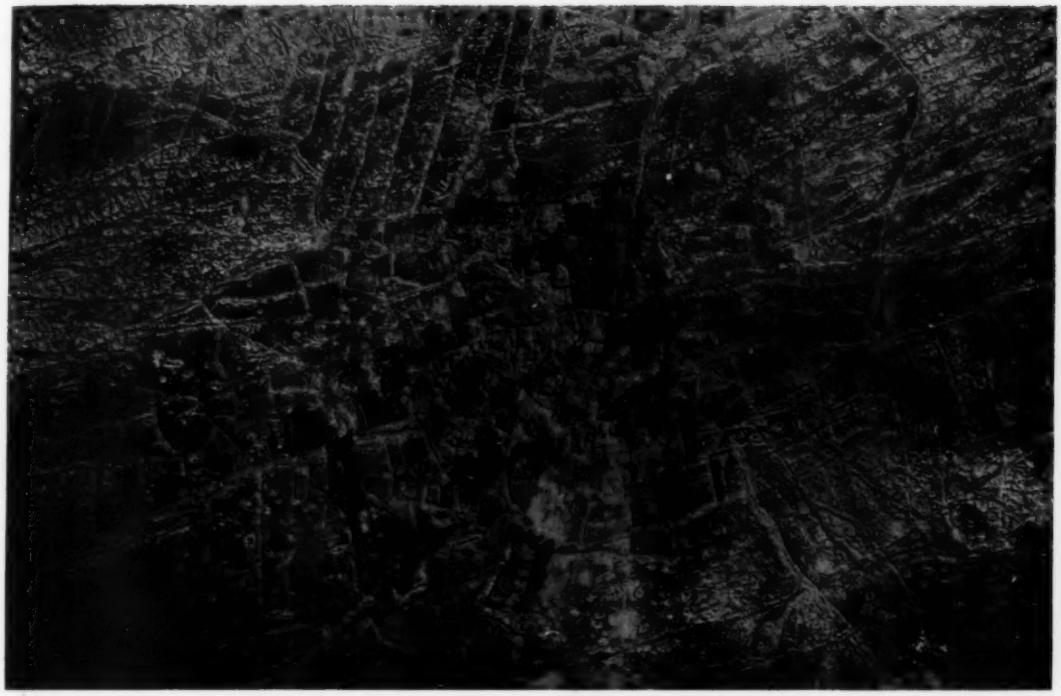
Section of the ancient Roman road from Aleppo to Antioch and passes through the northern portion of the Dead City area. The soil has been washed away from the road, leaving it standing in relief.

houses indicates that the inhabitants did not possess great territorial properties as did the Romans in Campania, Italy, Sicily, and North Africa. These Dead Cities, even in the more isolated regions were much too close together to allow for anything but intensive exploitation. Furthermore, the wealth could not have come from great herds, for the population required that the use of land be much more intensive than pasturage. These populous cities were doubtless supplied from the products of the immediate countrysides because there are no fertile areas in nearby plains accessible by roads to supply them with produce. They were self-sustaining and derived their wealth from exports of agricultural products.

Many olive oil and wine presses are to be found in the ruins, especially at Bara. There is what was obviously a large olive oil factory, with ruins of numerous presses and great bins. Mattern reports countless presses in his detailed examination of a large number of ruins. These presses are found everywhere on the ground floors of villas or in the neighboring houses in towns or in the cities. They were sometimes cut in the rock and most often were accompanied by reservoir cisterns such as can be noted at Bara and Gerade. Presses and cisterns were of many sizes. Often one finds them grouped, indicating that harvesting of a considerable area was carried out in common.

The olive and the vine doubtless provided the wealth and prosperity of the country. Wine and oil were two products which could easily be exported at good prices to Italy and the great cities of the west. The hill of Testaccio on the borders of the Tiber in Italy is entirely formed by the debris of the huge earthen jars of wine and oil which came by boat from the area of these Dead Cities, and were here transferred to smaller jars for sale. The great jars, characteristic of North Syria, were too numerous for further use in Italy. It does not seem that their return was considered feasible. And so important was the import of wine and oil that the broken jars when cast out during centuries of time had built up the unique hill of Testaccio. This remarkable hill gives some clue to the great production of this area in exportable wines and oil. The producers were enriched and the auxiliary industries shared in the prosperity of the land.

This region, before erosion transformed it into a desert, was well supplied with water. One finds stone spring houses beside springs which ceased to exist when the soil was removed by erosion. In some instances there appears to have been perennial water in the now dry streambeds. Moreover, these people were supplied with numerous and large cisterns, both in fields and towns. Each home was supplied with one or two cisterns within the walls to provide water supply during the rainless summer season. Many cisterns can be noted along paths and among the ruins. They are excavated out of the rock in the form of immense jars to protect them from caving in. The quarried stone was then used in the construction of buildings.



Aerial view of Hirbet Haas, southwest of Bara. Note the soil poverty of the area, and the marks of the old field boundary walls. The walls of the buildings are in a good state of repair. (Photo courtesy of Father J. Mattern.)

The evidence is that soil erosion was sufficient to destroy this area which supported a hundred or more prosperous cities of North Syria until 12 centuries ago. In a number of instances measurements have been made of the depth of soil which has been removed. For example, at the church of Mousabbak, the first steps begin at 4½ feet above the present ground or rock level. These lower blocks are foundation and undressed stones whereas 4½ feet higher the steps and stone work are dressed and polished. These foundation stones were formerly covered and have become bared since the ancient soil was washed away. Also, it is impossible to explain the use of certain olive oil presses except on the assumption that the soil was then 6½ feet deep over the present rock surface. This depth of soil must have been washed away. Soil wash is still continuing where any soil is left. Butler of the Princeton Expedition reports having observed the process during a winter storm. In some places caps of red soil still remain on the tops of mountains as at Djebel Sheikh Berekat or on level areas, and from these flow red streams of soil during the rainy season, giving a last example of what has gone on for centuries in North Syria.

It is not necessary to invoke adverse climatic changes to explain this desolation and desiccation of this ancient prosperous region. Wherever the walls of ruins prevented the soil from being washed away, vines, olive trees and shrubs are growing today. Bara is still noted for its vines, which are limited now to the few places where patches of soil are still found. Two miles south of Sunkhar a grove of trees appears as an oasis in a dreary gray land surrounding a high tower among the ruins, where a large pocket of soil has been held back on a flat protected by walls. The town is in ruins and the lofty tower rises in splendid isolation above the trees which occupy the only remaining soil in this region.

As in North China, North Africa, Trans-Jordan and elsewhere, soil erosion is clearly the principal agent in destroying the land and in undermining the civilization and culture which was dependent upon it. The early inhabitants found primeval forests here. Then began moderate clearing, deforestation and cultivation of slopes. Ancient cultivation up through the Roman period was intelligent and demonstrated an understanding on the part of the inhabitants of the conservation of soils and rain waters by terraces and check dams. At this time the region was highly prosperous, populous, and flourishing. But in A. D.

630 the Arab invasion swept away progress in agriculture. The vineyards and olive trees were destroyed, and the land was put under patch cultivation to grain crops and heavily grazed. After the destruction and dispersal of the former population, neglect of the land, especially under the Turkish domination of 400 years, brought on erosion of the soil. The hordes of invaders from the east and south, in their rapid passage, had neither the time nor the means to demolish the huge stone blocks comprising the great buildings. But by fire and the ax they destroyed the remaining forests as well as the plantations of olives and vines.

These nomad invaders have always shown themselves to be enemies of trees; their descendants have remained true to this hate, whether it be in North Africa, Syria or Trans-Jordan. The Arab nomads are spoken of as "sons of the desert", but in view of the deserts they and their goats have created, it would be more fitting to speak of them as "fathers of the desert." They pitch their black, batlike tents amidst ruins of the magnificence of the past and allow the terraces to break down and the soils to wash away. They permit their goats to destroy and trample out the former measures for conservation of soil and water. They practice a Neolithic type of agriculture; for they are always on the move and have little interest or inclination to protect the diminishing soils. The nomad invaders and their goats worked hand in hand with erosion to destroy the fertility of the lands.

These hundred or more Dead Cities are dead forever because their soils are gone beyond any hope of reclamation. The cities could be made habitable again with no great amount of work. The buildings would be more sumptuous than those in any of the Twentieth century towns and villages in this or surrounding areas. But when this good earth was sinned against it would not produce; it carries the curse of despoliation which continues to curse this region. Man and erosion have devastated this area for a geologic age. Here the "unpardonable sin" of land use has been committed.

Man-induced erosion of the soil has in this region of about 1,150,000 acres done its worst; it has swept 3 to 6 feet of soil from the hill lands, baring the limestone skeleton of the country. It has removed the support of the former prosperous population which found wealth and leisure enough to delight in and develop an art and architecture of unusual vigor and beauty. The people and the civilization vanished leaving the Dead Cities of North Syria as tombstones above a stark and barren landscape. They tell the tragic story of the terrible curse upon the land and future inhabitants when soil erosion is permitted to despoil the soil and water resources.

Literature

(1) Butler, H. C., American Archaeological Expedition to Syria in 1899–1900. Part II, Architecture and other Arts, New York, 1904.

(2) ——— Syria, Publications of the Princeton University Archaeological Expeditions to Syria in 1904–05 and 1909. Division II, Architecture, Section B, Northern Syria.

(3) ——— Early Churches in Syria, ed. by E. Baldwin Smith, Princeton, 1929.

(4) Mattern, S. J., Father J., A Travers les Villes Mortes de Haute Syrie, 1933, Imprimerie Catholique, Beyrouth.

(5) de Vogue, Syrie centrale, Architecture civile et religieuse du III^e^ au VII^e^ siecle. 2 in-4°. Paris, 1865–77.

FOR REFERENCE

(Continued from inside back cover)

Orchard Soil Management: Some Effects of Different Practices on the Soil. Bulletin No. 373. Agricultural Experiment Station, State College, Pa. February 1939.

A Preliminary Economic Appraisal of the Soil Conservation Program in the Beaver Run Watershed, Westmoreland County, Pennsylvania. Agricultural Experiment Station, State College, Pa., in cooperation with Soil Conservation Service and Bureau of Agricultural Economics, U. S. Department of Agriculture. September 1938. mm.

Socio-Economic Phases of Soil Conservation in the Tarkio Creek Area: Economics of Agricultural Land Use Adjustments, II. Research Bulletin 241. Agricultural Experiment Station, Ames, Iowa, in cooperation with Soil Conservation Service and Bureau of Agricultural Economics, U. S. Department of Agriculture. October 1938.

Some Economic and Social Aspects of Irrigation in Montana. Bulletin No. 354. Agricultural Experiment Station, Bozeman, Mont. January 1938.

The Tax System of Nebraska with Special Reference to Its Relation to Agriculture. Research Bulletin No. 105. Agricultural Experiment Station, Lincoln, Nebr. October 1938.

Vegetative Composition, Density, Grazing Capacity and Grazing Land Values in the Red Desert Area. Bulletin No. 229. Agricultural Experiment Station, Laramie, Wyo. July 1938.

Yield Tests and Land Valuation. Research Bulletin No. 252. Agricultural Experiment Station, Ames, Iowa. March 1939.

Miscellaneous

Analysis of Interregional Competition in Agriculture. Bureau of Agricultural Economics, U. S. Department of Agriculture. April 1939. mm.

Farming Hazards in the Drought Area. Research Monograph XVI. Works Progress Administration. 1938.

Sorting and Sampling Farms for Soil Conservation Research. Bureau of Agricultural Economics, U. S. Department of Agriculture. October 1939. mm.

A Study of Farming in the Gilmore Creek Soil Conservation Demonstration Area, Winona County, Minnesota. (Some Implications of the Recommended Soil and Water Conservation Program.) Soil Conservation Service and Bureau of Agricultural Economics, U. S. Department of Agriculture, in cooperation with Minnesota Agricultural Experiment Station. June 1939. mm.

FACTORS AFFECTING RUN-OFF FORECASTS BASED ON SNOW SURVEYS

(Continued from p. 151)

spring as determined by tests of the soil, ground-water levels and winter stream flow. To the same end, the possible significance of early fall and late spring rainfall is being investigated.

As a specific instance where the water supply forecasts have been of great value to irrigationists the case of Utah in 1934 is cited. Utah was one of the States having a State-wide snow survey program prior to 1935, and was thus prepared for the 1934 drought. The winter was extremely moderate. It was early indicated that there would be a water shortage, the extent of which was not known until the snow surveys were made on the principal watersheds of the State. During the midwinter snow surveys a marked deficiency of snow cover, a dry soil under the snow, and winter melting were found and were interpreted as pointing toward a serious water shortage. The more complete annual surveys made in April supported the earlier findings and emphasized the pending water shortage. This information was immediately publicized and put into the hands of irrigators, power companies, municipalities, and other water users. At first, many water users refused to recognize the seriousness of the situation. There followed a meeting of representative water users called by the Governor of the State to consider the situation. The gathering concluded that an emergency existed and the Governor, on the strength of this conviction, wired the Federal Government at Washington for assistance in combating the drought. An initial sum of $600,000 was granted the State and later the sum was augmented to an approximate total of about $1,400,000. At the same time a water conservation program was instituted. This comprised two lines of attack: First, the education of water users in methods of conservation and better use of water; and second, a survey of possibilities for developing supplementary water supplies that might be carried out through use of Federal funds. Both parts of the program were successful. Farmers were contacted in every irrigated community in the State and persuaded to put into effect prescribed water conservation measures. A water development program was executed with Federal funds which yielded approximately 400,000 acre-feet of water.

Estimates made at the end of the season indicated that a saving in crops alone of over $5,000,000 had been effected. In addition a tremendous saving resulted from feeding and removing range stock that otherwise would have succumbed for lack of pasture and water. Also, the water power companies were enabled by the advanced information to provide supplemental power in advance of its need. Furthermore, the program was followed closely by cities and towns, to the end that great inconvenience was avoided.

Besides these material savings there was also a spiritual benefit that is difficult to appraise. Farmers were saved the labor and cost of seed, which if spent, would have yielded them nothing. Water commissioners were given courage to distribute water with justice to all and favors to none. Maximum use of the water was made without causing jealousy and animosity among water users.

COOPERATIVE FARM FORESTRY

(Continued from p. 137)

research, and operations on the land. In all probability, the path will not always be smooth; obstacles and difficulties that cannot even be foreseen at this point will doubtless arise. But if the various State and Federal agencies work closely together, if they constantly improve their efforts through research and experience, and especially if they heed the wise counsel of cooperating farmers, the farm forestry work may prove eventually to be one of our most important avenues to better use of American land.

BOOK REVIEWS AND ABSTRACTS

by Phoebe O'Neall Faris

McMICHAEL'S APPRAISING MANUAL, 2d EDITION. By Stanley L. McMichael. New York. 1939.

Twenty new chapters have been added to this manual. In its first-edition form the volume has been widely used, for some years, by land and property appraisers. The new enlarged edition is reviewed here chiefly for the benefit of the land acquisition division personnel of the Service whose work in the field involves appraisal of land for soil conservation purposes. The book should be useful also to land owners, and for that matter to anyone who owns or contemplates owning anything in the way of real property.

New viewpoints on the appraising procedure and new standards of value are pointed out in the first chapter; and "value, its meaning and how to measure it' is treated in five succeeding chapters with special emphasis on management as a factor in estimating value, population growth or decline as influencing land or real estate values, shifting business and changing values, and the proper approach to the valuation estimate. Depreciation is then discussed at length, and the causes of economic, functional and physical depreciation are listed in convenient form, with numerous examples, so that the appraiser may have at hand a complete and handy reminder of all phases of valuation processes.

The "annuity approach" to calculating the present worth of estimated future benefits is set forth at some length in a chapter headed "Interest Tables and Their Uses" and a series of tables is included for rapid calculation appraising. Chapters 11 to 17 are devoted to the functions of the appraiser and directions for appraising specific properties—office buildings, apartment houses, warehouse properties, harbor and water-front holdings and gasoline stations. Then follows a special treatment of the appraising of agricultural lands:

Soil quality is given as of first importance as an appraisal asset in appraising agricultural land. The soil rating chart evolved by the staff of the College of Agriculture of the University of California is shown as a sample "measuring rod" to be used in distinguishing the nature and value of different soils encountered on a farm; and Jennings' informative rating chart for listing and comparing soil factors is included to point out soil profile, texture, surface relief, internal drainage, and alkali percentage as important points to be considered. Topography, water supply, pest control, fertilization, improvements, management and operation and cost records, county averages of valuation, and location of the land are discussed separately as features to be given careful consideration in farm appraisals. The complete statement of an actual farm appraisal is given with this chapter.

Another chapter that no doubt will be useful to land acquisition workers of the Service is that dealing with appraising for condemnation. This is pointed out as an extremely complicated branch of the appraisal activity, and the author has included all necessary information regarding factors to be considered for this type of appraisal.

Governmental activities that influence property valuation at the present time are discussed briefly in chapter 23. The remainder of the volume is devoted more or less to procedures for specialized appraisals—residential property, corner lots, triangular lots, odd-shaped properties, blighted areas, tree values, etc.

The book proper contains many charts, diagrams, tables and sample appraisals to be used as time and labor savers by appraisers, while in the appendix is to be found a great variety of information that serves as supplementary help.

DIRECTIONS FOR COLORING LANTERN SLIDES, TRANSPARENCIES AND PHOTOGRAPHS.

By Bernard L. Simmons. Mimeographed publication, Section of Information, Soil Conservation Service, Washington, D. C. May 1939.

This publication is designed especially as an aid to visual information artists throughout the Service whose duties include the preparation of colored photographic material. Lantern slide coloring is treated first, with directions for choosing, preparing and applying and blending the color. A sample slide is shown, with numbered sections, and by means of this device the artist is instructed in applying and blending color to trees, sky and clouds, fields in the foreground and hills in the background.

The correct way to color photographic transparencies with oil colors, using a light table, is carefully described as to type of color and thinning medium, applicators and light table, preparing the slick-surface transparency, and the actual work of applying the color. Brief directions are given for coloring photographs on glossy surface and on full-matte and semi-matte surfaces. Some helpful general suggestions are included at the end of the publication to help the colorist in refining his effects.

Mr. Simmons, the author, is in charge of the illustrations unit in the division of information, Soil Conservation Service, Washington, D. C.

GENERAL CARTOGRAPHY. By Erwin Raisz. New York. 1939.

This book is called to the attention of the many people in the Service who are interested either directly or indirectly in the art of map-making. The volume is divided into two parts, General Cartography and Special Maps. Under the first title the reader finds a rather extensive history of map-making—four chapters of history to be exact; and, following this, the specialized subjects relating to cartography are presented with great care for detail. The first of these subjects, scales and projections, leads into a discussion of the representation of the earth's pattern on maps and the composition and drafting of maps. Lettering is treated, also, as a special subject.

The second part of the book covers official and professional maps; diagrams, statistical maps, and cartograms; science maps and diagrams; globes, models, field sketching, and cataloging. One very unusual chapter treats of engraving and related subjects, and there are about 200 illustrations distributed throughout which contribute greatly to the value of the work to those directly concerned with the art of making and reproducing maps.

The new Yearbook of Agriculture (1939) is now available through the Office of the Superintendent of Documents. The large volume, entitled "Food and Life," deals with the nutrition of animals and human beings.

U. S. GOVERNMENT PRINTING OFFICE: 1939

SOIL CONSERVATION ENGINEERING

By T. B. CHAMBERS [1]

THE physical land-use adjustment programs—erosion control, irrigation and drainage, the farm phase of flood control, the water-facilities program, submarginal-land purchase and development, and farm forestry—are now a function of the Soil Conservation Service. The amalgamation of these varied activities has resulted in an enlargement or broadening of policies, and their administration has necessitated adjustments in the original Soil Conservation Service organization. Although all divisions of the Service have felt the effect in one way or another, the engineering work probably has increased more in variety and magnitude than any other branch. The primary purpose of the articles assembled in this issue of SOIL CONSERVATION, as in the January 1939 issue, is to point out in some detail the place, kind, and extent of engineering performed by the Soil Conservation Service, together with current problems, procedures, and progress.

The nature of the various programs now administered by the Service diverts automatically a large share of the field responsibilities to the engineers of the Service. The development of purchased submarginal lands involves a variety of engineering activities. Areas designated for grazing require extensive fencing and livestock watering developments. Roads, impounding dams, numerous types of buildings, as well as other structural improvements, are required on areas to be used for recreational and wildlife purposes. The transfer of the departmental drainage and irrigation activities, two well-established fields of engineering work, places additional responsibilities on the Service. The productivity of large agricultural areas is dependent upon proper design, installation, and maintenance of suitable drainage and irrigation systems.

The basic purpose of the Water Facilities Act is to promote proper land use by providing numerous engineering installations to conserve and utilize water for stock or domestic use or for application to farm gardens, crop or hay lands, range or pasture lands, or to other lands used for agricultural purposes. The hydrologic, sedimentation, and economic investigations in connection with the flood-control program present distinct engineering problems as well as the structural aspects. All these engineering activities must be executed in addition to the mechanical, structural, and other supplemental engineering measures required for an effective erosion-control program.

The engineering work of the Service is characterized by the diversity and magnitude of projects and problems encountered. In the broadest sense they are predominately agricultural engineering. To supplement modest farm incomes, natural resources must be fully utilized and other practical agricultural requirements must be met. It is not a spectacular type of work; it involves rather a variety of comparatively small works scattered over large areas, the majority of which must be applied on a farm-unit basis. Yet, to be well done it requires the highest type of engineering ability. The variety and multiplicity of units, as well as the development and standardization of techniques and methods to meet agricultural conditions, requires as much engineering resourcefulness as structural accomplishments noted for their technical complexity or grandeur. Furthermore, all activities must be fitted into a workable program that harmonizes with the ultimate land-use objectives of the Department of Agriculture.

As in all new engineering fields, there is a woeful lack of experience, precedent, and fundamental research information. Upon analysis, most problems require scientific data and tested practice for their solution. The same fundamentals of hydraulics, mathematics, physics, mechanics, etc., that are used in established engineering fields are necessary, but they require new applications. Agricultural engineers soon discovered that the prevention of erosion, the drainage of flat lands, or the irrigation of arid farms was not simply a matter of building structures or designing hydraulic channels. Of greater importance is the drafting of a comprehensive procedure to harmonize with proper land use, cropping requirements, variation in soil types, and farming practices or organization. Due to their training or natural inclinations, many engineers tend to limit their vision of specific problems to the immediate details of a ponderable mass of hydraulic or methematical formulations and to overlook the ultimate objective or proper application of engineering in agriculture. The adoption of a comprehensive view, without sacrificing necessary fundamentals, is essential for success. A distinct field of soil-conservation engineering unfolds therefrom.

[1] Chief, engineering division, Soil Conservation Service, Washington, D. C.

198670—40——1

Original field condition

TERRACE CONSTRUCTION IN SIX ROUNDS

End of first round

Fifth round

Completed terrace---sixth round

Third round

Adequate size was obtained in six rounds on this Louisiana terrace. Dirt was moved from the upper side only. This method is of particular advantage on the steeper slopes.